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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : B09B 1/00, G21F 9/16 E02D 5/18, G21F 9/18, 9/24 | A1

(11) International Publication Number: WO 86/ 01439

(43) International Publication Date: 13 March 1986 (13.03.86)

(21) International Application Number: PCT/US85/01656

(22) International Filing Date: 26 August 1985 (26.08.85)

(31) Priority Application Number: 646,745

(32) Priority Date: 4 September 1984 (04.09.84)

(33) Priority Country: US

(60) Parent Application or Grant
(63) Related by Continuation
US 646,745 (CIP)
Filed on 4 September 1984 (04.09.84)

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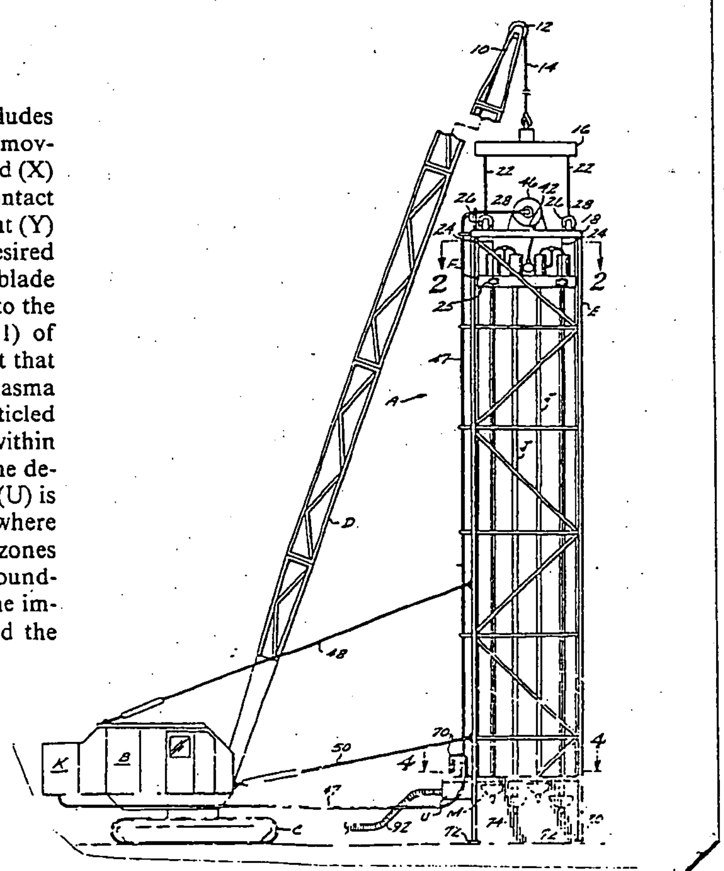
(81) Designated States: AT, AU, BB, BE (European patent), BG, BR, CF (OAPI patent), CG (OAPI patent), CH, CM (OAPI patent), DE, DK, FI, FR (European patent), GA (OAPI patent), GB, HU, JP, KP, KR, LK, LU, MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NO, RO, SD, SE, SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.
With amended claims.

(54) Title: *IN SITU* WASTE IMPOUNDMENT TREATING APPARATUS AND METHOD OF USING SAME

(57) Abstract

An apparatus (U) is shown in figures 11-13 that includes a power operated vehicle (V) that supports a vertically movable frame (W) that has a confined space defining shroud (X) on the lower end thereof that may be placed in sealing contact with the upper surface of a hazardous waste impoundment (Y) at a first station to permit the *in situ* detoxification of a desired portion of the impoundment. At least one power driven blade (Z) is rotated downwardly from within the shroud (X) into the impoundment to form a vertically extending zone (A-1) of particled material that is treated with a detoxifying agent that may be chemical, biological or heat from one or more plasma torches. Gases emitted during the formation of the particled zone (A-1) are subjected to scrub action by a liquid within shroud (X) and the liquid returned to zone (A-1). After the detoxification of a zone has been completed the apparatus (U) is moved to a succession of overlapping second stations where the above described method is repeated. The detoxified zones at the option of the user may encompass the entire impoundment, be in a configuration of a barrier that surrounds the impoundment, or a liner that extends downwardly around the periphery of the impoundment and thereunder.



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INSITU WASTE IMPOUNDMENT TREATING APPARATUS AND METHOD OF USING SAME

Description of the Prior Art

In various industries it has been common practise to discharge aqueous, dry or semi-solid waste chemicals or radioactive materials into ponds, which waste material after a period of time tends to become pasty or solid due to the evaporation of water therefrom. After the waste material has assumed a substantially solid state, dry particles thereof that are exposed to the ambient atmosphere tend to become airborne and are a health hazard. In addition, the toxic material in such an impoundment tends to leach into the soil adjacent thereto as well as contaminate ground water.

In the past, various methods have been proposed to lessen the danger inherant to such hazardous impounded materials, but such methods have not been effective. One such method includes the removable of a portion of the waste material, and erecting a concrete or betonite isolation wall in an attempt to contain the balance of the impounded material.

Also it has been proposed to excavate the impounded material and transport the same to existing or newly built disposal sites that may or may not be sealed with a liner. However, when either of the above identified methods is used, the impounded material is subjected to mechanical action that renders a portion of it airborne with consequent health hazards.

A major object of the present invention is to provide an insitu method of treating impounded toxic and radioactive materials, and an apparatus for carrying out the method that does not have the

operational disadvantage of prior art treatment methods, and one that transforms the impounded material into a solid substantially insoluble mass from which toxic materials will not leach out into adjoining land or water table, nor will any substantial surface particles of the mass become airborne even when the mass is subjected to elements of weather.

Another object of the invention is to supply a method of treating hazardous impounded materials in such a manner that the danger of transporting the same over public highways is eliminated.

A further object of the invention is to furnish a method of treating hazardous waste material that is more rapid in carrying out the less dangerous to the personnel involved than prior art methods that attempted to attain the same results.

A further object of the present invention is to treat an impoundment containing radioactive material to minimize the escape of radon gas therefrom and to render radioactive compounds in the impoundment insoluble to the extent that they will not leach out from the treated impoundment.

SUMMARY OF THE INVENTION

The insitu impoundment treating apparatus includes an assembly of adjacently disposed, power driven, rotating cutter-injectors supported on the lower ends of vertically disposed hollow kelly stems or drill pipe that may move up and down. The assembly is supported by a boom or the like that extends outwardly from a power driven vehicle such as a tractor pipelayer crane or the like. The boom supported assembly may be extended out over the impoundment a substantial distance, while the power driven vehicle remains on solid land adjacent the impoundment.

The assembly cutter-injectors are sequentially lowered into adjacent areas or stations of the impoundment while rotating to homogenize the hazardous waste material therein to a desired depth. After the desired depth has been reached, the cutter-injectors are moved upwardly while rotating, and simultaneously treatment chemicals for the hazardous waste material are injected therefrom.

The depth to which the cutter-injectors are moved downwardly and then raised upwardly as above described produce different results. If the cutter-injectors are moved downwardly and then upwardly in only the land beneath the impoundment, an impervious liner to contain the hazardous waste may be formed without removing the hazardous material from the impoundment. By lowering the cutter-injectors to the bottom of the impoundment and then raising them upwardly, the entire contents of the impoundment may be transformed to an inert insoluble mass that has substantial strength, and may remain in place.

Should the cutter-injectors be moved downwardly below the surface of the impoundment and then upwardly, a rigid cap of a desired thickness may be placed over the hazardous waste in the impoundment that will bear a substantial load and prevent particles of the hazardous waste becoming airborne.

Released odors or toxic vapors that escape from the hazardous waste material during the treatment thereof, and that are not destructed by the treatment chemicals, are reeded to the surface of the impoundment and collected for scrubbing within a confined space defined within a protective collection shroud that extends over the treating area.

The multi-head rotating cutter-injectors are so spaced that the circular area through which they rotate overlap to assure complete mixing of the hazardous waste material being treated and the treatment chemicals therewith. Engineering values of the treated material may be predetermined by bench testing representative samples or are taken periodically to determine shear compression, and the load bearing strength of the treated material, and on the basis of these results the rate of injection of the treatment chemicals is varied to obtain treated waste having desired physical characteristics.

The specific treatment chemical used will depend on the composition of the hazardous waste material which is determined by an analysis thereof. Waste materials found in impoundments include cyanide waste; toxic metals; metal plating waste; inorganic compounds that may be acid or base solvants and

reactive sludges; pestiside compounds; halogenate and nonhalogenate volatile organics, transformed from oil and the like. Impoundments may also contain drilling muds and fluids; oily waste sludges; pasty sludges; pharmaceutical, agrictural and municiple waste water sludges; and low level radioactive waste and uranium mill tailings.

The specific treatment chemicals selected for use at a particular impoundment can result in acqueous waste being dewatered and the volume thereof accordingly reduced.

Free standing liquids are blended with the solid fraction to eliminate the removal of the liquid phase. Toxic substances in the impoundment are transformed into a stable, inert, insoluble sedement which may be solidified into a nonpermeable matrix. Waste odors or toxic vapors arising during the impoundment treatment are either chemically destroyed, or scrubbed to remove objectionable components prior to being released to the ambient atmosphere.

Impounded hazardous waste are not removed from or surfaced on the impoundment during the present treatment method and exposure of workmen to toxic emitions is minimal or completely eliminated. Aqueous waste immediately after treatment are transformed into a dry, earthlike friable material that may be handled safely and transported by use of conventional earth moving equipment.

The major chemical use in carrying out the insitu treatment to immobilize, detoxify, destroy or precipitate the toxic substances and transform them into an insoluble state as well as into a

highly impermeable and dense matrix, includes limes in form of calcium oxide, calcium hydroxide and milk of lime and suitable clay products. Other chemical additives include a wide range of oxidizing additives of which sodium bisulfite, sodium hydrosulfite, chlorine dioxide, hydrogen peroxide, ozone and acids and alkaline products in various forms are examples. Other chemicals dependent on the composition of the waste material.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevational view of an apparatus for use in the insitu treatment of hazardous waste impoundments;

Figure 2 is a top plan view of a portion of the apparatus taken on the line 2-2 of Figure 1;

Figure 3 is a fragmentary vertical cross sectional view of a swivel assembly taken on the line 3-3 of Figure 2;

Figure 4 is a top plan view of a portion of the rotary table floor taken on the line 4-4 of Figure 1;

Figure 5 is a vertical cross sectional view of a portion of the cutter-injector driving mechanism taken on the line 5-5 of Figure 4;

Figure 6 is a side elevational view of one of the cutter-injectors;

Figure 7 is a fragmentary vertical cross sectional view of one of the cutter-injectors taken on the line 7-7 of Figure 6;

Figure 8 is a top plan view of a portion of the cutter-injector;

Figure 9 is a side elevational view of the lower portion of the apparatus holding a number adjacently disposed zones thoroughly mixed hazardous waste in an impoundment; and

Figure 10 is a top plan view of the apparatus adjacently disposed to an impoundment and moving the cutter-injector assembly from station to station to insoluablize and render inert the hazardous waste material.

Figure 11 is a perspective view of a second form of apparatus for use in the insitu treatment of hazardous waste impoundments;

Figure 12 is a side elevational view of the second form of apparatus;

Figure 13 is an end elevational view of the second form of apparatus;

Figure 14 is a horizontal cross sectional view of a portion of the second form of apparatus taken on the line 14-14 of Figure 13;

Figure 15 is a fragmentary vertical cross sectional view of the second form of apparatus taken on the line 15-15 of Figure 14;

Figure 16 is a horizontal cross sectional view of a portion of the second form of apparatus taken on the line 16-16 of Figure 15;

Figure 17 is a horizontal cross sectional view of a portion of the second form of apparatus taken on the line 17-17 of Figure 15;

Figure 18 is a bottom plan view of a portion of the second form of apparatus taken on the line 18-18 of Figure 15;

Figure 19 is a top plan view of a portion of the second form of apparatus taken on the line 19-19 of Figure 15;

Figure 20 is a diagrammatic view of the Kelly drive mechanism;

Figure 21 is a side elevational view of the intermediate platform moving mechanism;

Figures 22, 23 and 24 are side elevational views of first, second and third forms of cutting blades;

Figure 25 is a front elevational view of the interior of the shroud in which spray water and liquid reagents are discharged to remove toxic gases from air prior to discharge to the ambient atmosphere;

Figure 26 illustrates the forming of a downwardly extending zone of hazardous waste into a particled form;

Figure 27 illustrates the overlapping counter rotation action of a pair of adjacently disposed power driven blades;

Figure 28 is a diagrammatic layout of the sensing equipment used in the computer controlled insitu treatment of hazardous waste impoundments, and;

Figure 29 is a diagrammatic view of the lower end of a tubular Kelly that supports a number of plasma torches that provide sufficient heat to transform zone A-1 to a vitrified mass.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus A used in carrying out the insitu method of treating hazardous waste impoundment includes a power operated vehicle B that is preferably mounted on caterpillar track C to permit the vehicle to travel over soft ground. A boom D is pivotally supported from the vehicle B and extends upwardly and outwardly therefrom as shown in Figure 1. The boom D is angularly adjustable relative to the vehicle by conventional means (not shown).

The boom D has an outer end 10 that rotatably supports a pulley 12 over which a winch operated first cable 14 passes to extend downwardly to a support 16. An elongate vertical framework E is provided that has an upper end portion 18 and a lower end portion 20. A number of second cables 22 extend downwardly from the support 16 and are secured to the upper end portion 18 of the framework.

A horizontal vertically movable platform F is disposed within the framework E and is moved upwardly and downwardly by a number of spaced hoist and crown chain belts 24 that engage upper and lower sprockets 26 mounted on the framework E, but with only the upper sprockets being shown. The platform F is secured to one of the reaches of the belts 24 by conventional means 25. The sprockets 26 are secured to shafts (not shown) that are driven by motors 28 as may be seen in Figure 1.

A number of inverted cup shaped housings G are supported on the platform F as may be seen in Figure 2 and are arranged in four rows, each of

which rows includes four housings. Each housing G includes an upper end 30 from which a hook 32 extends downwardly to support a conventional oil well swivel H.

A number of hollow kelly stems J are provided and have their upper ends rotatably supported by the swivels H as shown in Figure 3. Each swivel H has a first hose 34 connected thereto as shown in Figure 3, with the hose being in communication with a passage 36 that extends downwardly in one of the kelly stems J. Each of the hoses 34 is connected to a tubular member assembly 38 that is in communication with an elongate manifold 40.

A second hose 42 is connected to a centered opening 44 in manifold 40, with the second hose extending to a reel 46. Reel 46 is supported on the upper portion of framework E. A third hose 47 extends from reel 46 downwardly alongside framework E to a facility K that serves to store chemicals, chemical blending and proportioning apparatus, a compressor, and pump for discharging dry chemicals and chemical solutions into the third hose 47. This facility is not shown in detail as all of the equipment therein is conventional and may be purchased in the present day commercial equipment market. The vehicle B has stabilizing members 48 and 50 extending therefrom to the framework E.

A rotary table L is mounted on the lower portion of the framework E and as may be seen in Figure 5 is defined by two parallel, vertically spaced plates 52 that are secured together in fixed relationship by conventional means (not shown).

One half of the rotary table is shown in Figure 4, with the other half being of the same structure. A number of ball bearings 54 engage grooves 56a in a pair of ring gears 56. The ball bearings 54 rotatably support the pair of ring gears 56 between the plates. Ring gears 56 have interior and exterior teeth 56a and 56b. Exterior teeth 56b are in engagement as shown in Figure 4. Eight sprockets 58 are disposed between the plates 52 and are arranged in two rows of four sprockets each.

Each sprocket 58 includes a hub 58a that is rotatably supported in a bearing 60 that engages the pair of plates 52. The bearings 60 are held in place on the rotary table L by retaining members 62 that are secured to plates 52 by bolts 64.

Each of the hubs 52a has a sleeve 66 extending therethrough, with the sleeve having a passage of square transverse cross section therein that is slidably engaged by one of the hollow kelly stems J that is also of square transverse cross section. A driving gear 68 engages the external threads 56b of one of the ring gears 56 as shown in Figure 4, with the gears being rotated by a motor 70 shown in Figure 1. The half of the rotary table L (not shown) in Figure 4 is of the same structure as that illustrated and is also driven by a second motor (not shown). The framework E has pads 72 secured to the lower portion thereof to permit the framework to be rested and supported on solid ground. A shroud 74 of pliable material extends downwardly from the periphery of the rotary table L as shown in Figure 1 and is preferably of a length to extend below the pads 74 when the shroud is fully stretched out.

Each kelly stem J supports a cutter-injector M on the lower end thereof, the detail structure of one of the cutter-injectors being shown in Figure 6. Each cutter-injector M includes a rigid elongate vertically disposable member 76 that has the upper end secured to a tubular collar 70a by welding beads 80, and the collar in turn secures the lower end of a kelly stem J by second welding beads 82.

Two first straight straps 84 of opposite pitch are axially aligned and extend outwardly in opposite directions from the member 76. The straps 84 on the outer ends develop into second straps 86 of arcuate shape that extend downwardly and inwardly to be secured to the member 76. The second straps 86 are also of opposite pitch. The hollow tubular member 76 has a bladed auger 88 secured to the lower end thereof. A tubular member 90 extends outwardly from the hollow vertical member 76 adjacent the first straps, and serves to have hazardous waste treatment chemicals discharged outwardly therethrough.

Treatment of an impoundment P containing hazardous waste R is carried out by the apparatus A, which apparatus is illustrated as a crane in Figure 1, in the following manner. The apparatus A is moved to land S adjacent an impoundment P as shown in Figure 9 and the boom D extending outwardly over the impoundment to position the framework E thereover as illustrated in Figure 10. The kelly stems J are concurrently rotated and the platform F lowered to allow the cutter-injectors M to move downwardly through the hazardous waste R at a station T, a series of which adjacent stations are shown in Figure 10. Each of the cutter-injectors M as it rotates

cuts and intermixes the waste R in a circular downwardly extending zone R-1 as shown in phantom line in Figure 8. The adjacently disposed cutter-injectors M are of such transverse dimensions that the zones of one R-1 overlap one another as illustrated by phantom line in Figure 8, and it is to these zones that the treatment chemicals are discharged.

The assembly K is used to discharge appropriate chemicals either dry, wet, or gaseous at a desired rate, to the cutter-injectors M, which discharge if desired may take place as the zones R-1 are formed to a desired depth.

The augers 88 allow a hard material to be penetrated as the cutter-injectors move downwardly through the waste R. The waste R that is mixed to a uniform consistancy in the zones R-1 remains in place therein, and due to the pitch of the straps 84 and 86 and the opposite rotation of adjacent cutter-injectors M the waste in one zone R-1 will be subjected to an upward force and the waste in an adjacent zone a downward force to obtain optimum intermixing of the waste. The discharging chemicals flow from the tubular member 90 as the cutter-injectors M rotate. After the zones R-1 have been formed the platform F is moved upwardly to cause the cutter-injectors M to rise through the zones R-1 with continued rotation of the cutter-injectors. If chemicals have not been injected into the waste R as the zones R-1 are formed, the chemicals are injected on the upward movement of the cutter-injectors M through the zones R-1. On occasion it may be desirable to inject chemicals into zones R-1 both as they are formed, and as the cutter-injectors are moved upwardly therethrough. Vapors, odors or omissions from the waste R that are not chemically destroyed during the formation of the

zones R-1 and the injection of chemicals therein, are collected in the confined space within the end shroud 74 and discharged through a conventional scrubber U to be removed, after which air free of the objectionable omissions is caused to flow through a conduit 92 for discharge to the ambient atmosphere of a desired location.

A second form of apparatus U is shown in Figures 11-13 that may be used in the detoxifying of a hazardous waste impoundment Y and is the best mode for accomplishing this result. Apparatus U includes a power operated vehicle V which in Figures 10-13 is illustrated as a caterpillar type tractor that movably supports a vertically extending frame W and an instrumentation and control cab 100. The frame W extends vertically and is of an open elongate shape. The frame W as shown in Figure 11 is defined by four elongate corner members 102 between which cross pieces 104 and reinforcing member 106 extend. The frame W includes an upper platform 108 and lower platform 110 rigidly secured thereto. An intermediate platform 112 shown in Figure 12 is situated within the frame W and is vertically movable relative thereto.

The frame W is vertically movable relative to a support assembly 114. The support assembly 114 has a number of elongate support members 116 extending therefrom to the vehicle V as shown in Figure 13. The support members 116 at their outer ends are secured to support assembly 114 by pivotal connections 116a and to the vehicle V by pivotal connections 116b.

A counterweight 118 by a conventional linkage assembly 120 is movably supported from vehicle V on the side thereof opposite that from which frame W is supported. A first hydraulic cylinder assembly 122

is pivotally connected to the vehicle V and linkage assembly 120 to permit lateral movement of frame W and support assembly 114 relative to vehicle V when the hydraulic cylinder assembly is activated. A second hydraulic cylinder assembly 124 is pivotally connected to support assembly 114 and frame W to permit vertical movement of frame W relative to the support assembly 114 and vehicle V when the second hydraulic cylinder assembly is activated.

A confined space defining shroud X extends downwardly from lower platform 110 into which a power driven rotatable cutting blade Z is vertically movable. A laterally spaced pair of motors 126 are mounted on lower platform 110 and rotate drive sprockets 128. Each drive sprocket 128 engages an upwardly extending endless link belt 130 that rotatably engages a pair of sprockets 132 rotatably supported from upper platform 108. Intermediate platform 112 is secured by conventional fastening means 112a to a vertical reach 130a of belt 130.

The lower platform 110 has two pairs of electric motors 134 mounted thereon that rotate driving sprockets 136 as shown in Figures 14 and 20 that are in toothed engagement with a pair of driven gears 138, which gears are also in toothed engagement.

The lower platform 110 as may be seen in Figure 15 is defined by an upper horizontal plate 110a and lower plate 110b. Each gear 138 is ring shaped and is rotatably supported by a sequence of ball bearings 140 from a ring shaped mounting assembly 142 that is secured to lower plate 110b by bolts 144 as shown in Figure 15.

Each driven gear 138 has a flat rigid ring shaped member 146 secured to the upper surface thereof by bolts 148 as shown in Figure 15. Each member 146 has a cylindrical sleeve 150 projecting upwardly therefrom and passing through an opening 152 in upper

plate 110a. In Figure 15 it will be seen that each sleeve 150 has a flange 154 projecting outwardly therefrom that supports a seal 156 in sliding contact with the upper surface of upper plate 110a.

In Figures 14 and 16 it will be seen that two spaced pairs of rollers 158 are rotatably supported above upper plate 110a from lugs 160 that are secured to members 146.

The intermediate platform 112 as may be seen in Figure 15 is defined by upper and lower vertically spaced rigid ring shaped horizontal plates 112a and 112b that are joined by connectors 162. Two tubular Kellys 164 used in driving blades Z have upper end portions 164a disposed within intermediate platform 112. Each end portion 164a has an outwardly extending flange 166 secured thereto, which flange has an externally grooved ring shaped member 168 secured thereto that rotatably engages a sequence of ball bearings 170 that engage an internally grooved ring shaped member 172 secured to the upper plate 112a of intermediate platform 112.

Kelly 164 has two oppositely disposed vertically extending ribs 174 projecting outwardly from the external surface thereof as shown in Figure 16, which ribs are rotatably engaged by the two pairs of rollers 158. Kelly 164 has a horizontal member 164a secured to the lower end thereof that supports a centrally disposed tubular member 176 of substantially smaller diameter than that of Kelly 164. Tubular member 176 serves as a mounting for a tube 178 that extends upwardly in Kelly 164, which tube has an outwardly extending seal 180 on the upper end thereof. The lower end of tubular member 176 develops into an outwardly extending flange 182.

Tubular member 176 rotatably supports a bushing 184 between member 164a and flange 182. The two bushings 184 rotatably engage cylindrical shells 186 that are connected by arms 188 of an open rectangular frame 190. The frame 190 on the periphery thereof supports a conduit 192 that has spray heads 194 mounted thereon, the purpose of which will later be explained.

Cutting blade Z illustrated in Figure 15 includes an outer tube 196 that has a pointed lower end 196a and the upper end of the tube being secured to a circular plate 198 that has a centered opening 198a therein. An inner tube 200 is secured to plate 198 and is in communication with opening 198. Inner tube 200 on the lower end develops into a discharge nozzle 202 that extends through outer tube 196.

Two oppositely disposed cutting blades 204 extend outwardly from the lower end of outer tube 196 and support a number of spaced teeth 206. Two arcuate cutting members 208 extend upwardly from the outer ends of blades 204 to outer tube 196 as shown in Figure 15. Circular plate 198 is secured to flange 182 by conventional means such as bolts 210 or the like.

The seal 180 engages the interior surface of an intermediately positional tube 212 that extends downwardly between Kelly 164 and inner tube 178. A tube extension 214 projects upwardly from tube 212 and is secured thereto by a ring shaped end piece 216 as shown in Figure 15. In Figure 16 it will be seen that Kelly 164 has two groove defining ribs 218 on the interior thereof that slidably engage to the exterior surface of tube 212.

Two inverted U-shaped tubular fittings 222 are mounted on upper platform 108 and are supplied air under pressure from two pipes 224 that are in communication with an air blower assembly 226 mounted

on vehicle V as illustrated in Figure 12. Two pipes 228 extend downwardly from fittings 222 to two tubular swivels 230, with the lower ends of the swivels connected to the tube extensions 212 as shown in Figure 13.

In Figures 15 and 18 it will be seen that a tubular rectangular frame 232 is supported from the underside of lower plate 110b within shroud X and has spray nozzles 234 extending outwardly therefrom. Circular tubes 236 are supported from lower plate 110b and extend around Kellys 164 and support nozzles 238. Liquid under pressure is supplied to tubular frame 232 by a pipe 240 and to circular tubes 236 by a pipe 242. The liquid supplied to tubular frame 232 and circular tubes may be water to not only form sprays to scrub gases from the air in shroud X, but also to wash toxic material from Kellys as the detoxification of impoundment Y proceeds. Toxic gases that arise during the detoxification of impoundment Y are prevented from escaping upwardly around Kellys 164 by tubular bellows 244 that envelop the Kellys. The lower end of the bellows 244 are secured to lugs 160 by conventional means and the upper ends of the bellows to the lower surface of intermediate platform 112.

Prior to using the apparatus U it is desirable that an underground radar scan be made of the hazardous waste impoundment to locate buried drums, tanks, barrels, and the like that may contain extremely dangerous materials. Suitable precautions must be taken when detoxifying the portions of the impoundment Y adjacent thereto.

After obtaining the above information, as well as an analysis of a sample of the hazardous waste impoundment Y to obtain the composition thereof, the apparatus U is moved to a first station as shown in Figure 25 adjacent the impoundment and the frame W

moved to dispose the shroud X in sealing contact with the upper surface of impoundment Y.

The motors 134 are now caused to drive the members 146 with the rollers 158 exerting a rotational force on the ribs 174 to rotate Kellys 164 and the cutting blade Z. Motors 126 are now energized to drive belts 130 to move intermediate platform 112 downwardly to exert a downward force on Kellys 164. Rotation of Kelly 164 is accompanied by the concurrent rotation of tubes 176, 178, 212, and 200, and pressurized air may now be discharged downwardly there through from blower assembly 226 to exit through nozzle 202.

Operation of the apparatus U results in the forming of a downwardly extending zone A-1 of particled hazardous waste impoundment material as shown in Figure 26. If the detoxifying agent is a dry powdered material it is introduced into the air stream from blower assembly 226 to discharge from nozzle 202. As the forming of zone A-1 takes place a pressurized liquid is discharged from the nozzles 194 to assist cutting blade Z in forming zone A-1 and reducing the size of the particles. Discharge of liquid from nozzles 194 causes the formation of a layer of turbulent liquid and particles above the blade Z which acts as a vertically movable seal to minimize the upward flow of toxic gases in zone A-1 into the interior of shroud X, and toxic gases below the seal being detoxified by the detoxifying agent.

Toxic gases that flow upwardly into the shroud X are scrubbed therefrom by a series of liquid spray from nozzles 234 and 238, prior to air from shroud X being discharged to the ambient atmosphere. The liquid serving as the scrubbing agent flows downwardly into zone A-1 and is detoxified therein. Toxic gases from zone A-1 are prevented from flowing upwardly around Kelly 164 to the ambient atmosphere, due to the

portion of the Kelly above the lower platform being encased in the longitudinally movable bellows 224. After the detoxifying method has been performed at a first station the apparatus U is returned to its initial position and subsequently moved to a sequence of second stations where the above described method is repeated.

Although the method has been described with the use of pressurized air to displace toxic gases from the particled material in zone A-1., steam may be used for this purpose. Use of steam is desirable when the hazardous waste contains substantial quantities of volatile organic components. The pair of concurrently rotating blades Z do not interfere with one another due to the gears 138 being in toothed engagement as shown in Figure 20.

The rotating blades Z particle the hazardous material in zone A-1 without the particled material being appreciably discharged upwardly therefrom. First, second and third alternate forms of blades Z-1, Z-2 and Z-3 are shown in Figures 22, 23 and 24, each of which includes a pair of oppositely disposed arms 244 secured to outer tube 196 and have arcuate cutting blades 244 extending downwardly therefrom to the outer tube. The third alternate form Z-3 includes a special cutting member 248 and teeth 250 secured to outer tube 196.

Instead of using a chemical detoxifying agent, the apparatus U may be used to introduce microorganisms into the zone A-1 to detoxify the latter. The microorganisms are either those already present in the impoundment Y or microorganisms that have been genetically engineered to biodegrade the hazardous material. The introduction of the microorganisms is accompanied with a liquid nutrient therefor .

An assembly is shown diagrammatically in Figure 28 that permits the composition of the hazardous waste impoundment to be determined as the zones A-1

are formed and the amount of detoxifying agent necessary to treat the same being determined by a computer system. A frame 248 is supported from tubes 196 above cutting blades Z, which frame supports a jetting assembly 250.

A liquid wetting reagent or dionized water from a storage tank 252 is fed by pump 254 through line 256 into flushing jet assembly 250 as shown in Figure 12B. The jetting assembly 256 erodes or displaces or washes the contaminated waste, causing the wash water to surround the sampling device and probes later to be described mounted on frame 244. The wash water containing waste contaminants can be sampled or be in contact with the probes at any preprogrammed depth of the zone A-1.

The sampling device shown as 258 picks up the flushed water and removing such water through line 260, the water pick-up is achieved by vacuum pump 262 and routed to the receiving chambers of an ICP Spectrometer or such suitable equipment shown as 262, for the screening of such toxic elements as heavy metals; to a radiation detector or such suitable equipment shown as 264 for the screening of radactive substances; to a reactivity and conductivity analyser shown as 266 for screening the sampled water for such properties; to a biological analyser or such suitable equipment shown as 268 to characterize the biological properties therein or to preprep such samples for traditional laboratory analysis.

The PH and Oxidation Reduction Potential (ORP) probe shown as 270 signals the PH and ORP of the wash water and transmits such signals to the PH and ORP meter shown as 272.

The temperature and moisture content probe shown as 272 transmits signals through cable 274 to temperature and moisture meter shown as 276.

Gases or vapors that may be released from the subsurface contents during mixing and homogenization are collected in shroud X, such liberated gases or vapors are collected by sensor 278 mounted on the shroud X. Such gases are routed to the photoionization detector or similar equipment and are screened for a wide range of chemical organic compounds, volatiles, and explosive vapors.

The photoionization detector or suitable similar equipment is shown as 280.

Sensor 278 also directs gases and vapors from zone A-1 to Sulfur Dioxide and Hydrogen Sulfide Detector shown as 282 measuring the concentration levels of those elements.

The data acquired from the ICP Spectrometer 262; The Radiation Detector 264; the Reactivity and conductivity analyzer 266; the Biological Analyzer 268; the PH and ORP meter 272; the Temperature and moisture meter 274; the Photoionization detector 280 and the Sulfur Dioxide and Hydrogen Sulfide Detector 282 are signaled to the data scan and interface analyzer and controller 284, then routed to the treatment menu programmer interface system 286 which determines the specific treatment parameter and treatment media dosage rate trigerring feeder shwon as 288, for the programmed feeding of the treatment media from the pneumatic chemical tanks shown as 290, such treatment media may include chemical reagents, bacteria, bacteria nutrients and oxygen generating chemicals. The selected treatment media is then fed into the Kellys 164 through top thereof as shown by line 224, for the integration with the subsurface waste. During the treatment stages all data aquisition systems earlier described are used where specifically needed for the characterization of the chemically or biologically improved subsurface contents. Gases and emissions are released from shroud X to scrubber 294 through a line 296.

The data acquisition and analyzer equipment are not limited to those described above, and equipment or analyzers similar in function or purpose may be incorporated, since contaminants present in hazardous waste sites are not typical but in general can be found to be highly variable and complex.

During the scrubbing of liberated gases or vapors by scrubber 294, the released and scrubbed emissions are routed through bypass shown at 296 to the photoionization detector 280 or Sulfur Dioxide and Hygrogen Sulfide detector shown as 282 to determine released compliance, or by pass 296 may be connected to an emission analyzer and the results of such data signalled to the data scan shown as 284.

The plasticity meter shown as 298 acquires placticity or density of the contents of zone A-1 from the alternating power-load of the Kelly drive motors 134. Such data characterizes the completion of the solidification of the subsurface contents if the preferred treatment of the waste contents require solidification thereof. The RPM meter shown as 300 acquires such data from the Kelly drive motors 134. The vertical travel depth and speed of blades Z is screened by scanner 302, acquiring such data from a vertical travel monitor shown at 304.

All acquired data from the Plasticity Meter 298, RPM meter 300 and Vertical Travel devices 302 and 304 are signalled to the Treatment Program Interface System 286 for incorporation into the preferred treatment of the hazardous material in zone A-1.

In addition to the detoxifications previously described, the apparatus U may be used to vitrify zone A-1 if the same is of a sandy or clay composition. Such vitrification is accomplished by the use of plasma torches 350 held in the lower ends of tubes 196 by supports 352 as shown in Figure 29. After the zone A-1

has been particled by use of blades Z, the blades are moved upwardly therein and the material therebelow is subjected to plasma arcs to melt and subsequently cool to a vitrified, nonsoluble, rigid mass. In the event the hazardous waste in zone A-1 does not contain sufficient sand or clay to vitrify, sand, clay or other vitrifiable material is added thereto through Ke-lys 164 by an air stream during the forming of the hazardous waste into particles. The use and operation of the invention has been described previously in detail and need not be repeated.

WHAT IS CLAIMED IS:

1. In combination with a source of chemicals that solidify and insolubilize salts of toxic metals in a hazardous waste impoundment, an apparatus for insitu application of said chemicals to said impoundment to transform said waste into an inert mass, said apparatus including:

a. a plurality of cutter-injectors, each of which when rotated and moved downwardly through said hazardous waste transforming a vertically extending zone thereof to a substantially homogeneous consistency;

b. an elongate vertically disposed framework;

c. a plurality of vertically disposed hollow kelly stems that have upper and lower ends, said cutter-injectors secured to said lower ends;

d. a plurality of swivels that rotatably support said upper ends of said kelly stems in spaced relationship;

e. a platform that is vertically movable in said framework and that supports said swivels;

f. first means for concurrently moving said platform swivels and kelly stems vertically in said framework;

g. power driven rotary table means on said framework for rotating said kelly stems by slidably engaging the latter as they are moved vertically by said first means;

h. a power operated vehicle;

i. second means for movably supporting said framework from said power operated vehicle outwardly over said hazardous waste impoundment

while said power operated vehicle remains on land adjacent thereto to permit said cutter-injectors to form a plurality of said zones at successive stations on said hazardous waste impoundment; and

j. third means for discharging said chemicals downwardly through said kelly stems to said cutter-injectors, said discharge taking place as said cutter-injectors are rotated and moved vertically in said zones to allow said chemicals to transform said homogenized hazardous waste in said zones to an inert insoluble material.

2. An apparatus as defined in claim 1 in which said kelly stems and swivels are so spaced that said zones as formed overlap one another to assure that all hazardous waste at a station on said impoundment has been transformed to a homogenized mixture.

3. An apparatus as defined in claim 1 which in addition includes:

k. third means for collecting gaseous products discharged from said zones as the hazardous waste defining same is transformed to a homogeneous mixture; and

l. fourth means for scrubbing undesirable components from said collected gaseous products prior to allowing said gaseous products to escape to the ambient atmosphere adjacent said impoundment and intermix therewith.

4. An apparatus as defined in claim 1 in which said second means is a boom that extends outwardly from said power vehicle and can pivot relative thereto, said boom having an outer end, and fourth means for supporting said framework from said outer end to permit said framework to be successively disposed at a plurality of said stations.

5. An apparatus as defined in claim 3 in which said third means is a pliable shroud that extends downwardly from said rotary table means to at least the upper surface of said hazardous waste impoundment to provide a confined space into which said gaseous products discharge, with said confined space in communication with said fourth means.

6. An insitu method of treating an impoundment of hazardous waste that may contain soluble salts of toxic metals into an insoluble, solid, inert material that may remain in place without danger of said toxic metals leaching therefrom, said method comprising the steps of:

a. rotating a plurality of adjacently disposed cutting blades downwardly through said waste to form a plurality of vertically disposed overlapping zones of homogenized waste at a first station in said impoundment, which homogenized waste is allowed to remain in place;

b. rotating said plurality of blades and moving them upwardly through said plurality of sections of homogenized waste;

c. concurrently injecting at least one chemical into said zones of homogenized waste adjacent said blades as said blades are moved upwardly through said zones, said chemical being one that reacts with said waste to transform said waste into a solid, inert, insoluble mass from which said toxic metals will not leach out over a period of time to land or a water table adjacent said impoundment; and

d. repeating said waste insolubilizing operation at a second station adjacent said first station and so continuing until all of said impoundment has been treated.

7. An insitu method of treatment as defined in claim 6 in which said zones extend to the bottom of said impoundment and all of said toxic waste in said impoundment has been rendered solid, inert and insoluble after said method of treating has been completed.

8. An insitu method of treatment as defined in claim 6 in which said zones extend downwardly a desired depth below the upper surface of said impoundment, with said method of treatment resulting in a cap of solid, inert, insoluble material that overlies untreated waste in said impoundment.

9. An insitu method as defined in claim 6 in which said hazardous waste may contain radium 226 and thorium 230 from which radon is emitted due to radioactive decay, with said chemical being added in an amount sufficient to precipitate said radium and thorium to prevent said decay and transform them and said hazardous waste into a solid, inert insoluble mass of such high density that the rate of migration of radon therethrough is slowed to the extent that the major portion of the radon transforms to a solid radionuclide element prior to reaching the ambient atmosphere to contaminate the latter, with waste radionuclide element being rendered insoluble by contact with said chemical and remaining in place in said insoluble mass.

10. An insitu method of treatment as defined in claim 6 which includes the further steps of:

e. recovering gaseous products discharging from said waste as a result of forming said sections;

f. scrubbing undesirable chemical compounds from said gaseous products; and

g. discharging said gaseous products free of said undesirable chemical compounds to the ambient atmosphere.

11. An insitu method of treating an impoundment of hazardous waste that may range in consistency from liquid to a paste that overlies soil of a clay like nature to provide a liner of solid insoluble material for said hazardous waste without removing said hazardous waste from said impoundment that includes the steps of:

a. lowering a plurality of adjacently disposed cutting blades downwardly through said hazardous waste to contact the soil at the bottom of said impoundment;

b. rotating said blades and moving them downwardly in said soil to form a plurality of vertically disposed overlapping zones of homogenized soil to a depth that is to be substantially the thickness of said liner;

c. rotating said plurality of blades and moving them upwardly through said plurality of zones of homogenized soil;

d. concurrently injection calciumoxide into said sections as said blades are moved upwardly through said sections of said calciumoxide to react exothermically with said clay like soil to transform the latter to a solid, insoluble mass of substantial strength that defines said liner that is impervious to said waste situated thereabove; and

e. repeating said soil insolubilizing operation at a second station adjacent said first station and so continuing until said liner has been formed to underlie all of said hazardous waste.

12. An insitu method as defined in claim 11 which includes the further steps of placing a cap over said hazardous waste by the method defined in claim 8.

13. An insitu method as defined in claim 6 in which said blade includes a pair of oppositely pitched portions to impart a downward and upward screwing action to said hazardous waste to obtain optimum homogenization of said waste as well as optimum mixing effeciency of said chemical therewith.

14. An insitu method as defined in claim 6 in which said chemical is selected from the group comprising calciumoxide, sodium bisulfite and sodium hydrosulfite.

15. A method of stabilizing and insolubilizing an impoundment of hazardous waste material that contains water and may contain waste hydrocarbon products in the form of oils and solvents and soluble salts of toxic metals which includes the steps of:

a. forming a plurality of adjacently disposed vertically extending zones in said impoundment that are defined by particles thereof;

b. saponifying said waste hydrocarbon products in said zones to an insoluble mass; and

c. oxidizing said soluble salts of toxic metals in said zones to a substantially insoluble state.

16. A method as defined in claim 15 in which said zones are mixed and treated by concurrently rotating and moving downwardly in said impoundment a plurality of convex-concave rigid blades, and leaving the cuttings resulting from the rotation of said blades in said mass impoundment to provide said particles.

17. A method as defined in claim 16 in which said solidification of said waste hydrocarbon products and toxic metal salts is achieved by reversing the direction of rotation of said blades and moving said blades upwardly in said impoundment to intermix said particles and concurrently discharging calcium oxide into said bore holes adjacent said blades, said calcium oxide interacting with said water in said particles to provide an exothermic reaction in which said hydrocarbon or radioactive products are transformed to a solid water insoluble mass, and said water soluble salts of said toxic metals are transformed to substantially water insoluble oxides.

18. A method as defined in claim 17 which in addition includes the step of discharging sodium bisulfite into said zones with said calcium-oxide to augment the oxidizing of said soluble salts to said insoluble oxides.

19. A method as defined in claim 17 which in addition includes the step of discharging sodium hydrosulfite into said impoundment with said calcium-oxide to augment the oxidizing of said soluble salts to insoluble oxides.

20. A method as defined in claim 15 which includes the further step of:

d. establishing a pH of between 8.0 to 11.0 on said particles in said zones to facilitate said oxiding of said soluble salts of toxic metals to a substantially insoluble state.

21. A method of stabilizing and insolubilizing an impoundment of hazardous waste material that may contain waste hydrocarbon material in the form of oils and solvents and soluble salts of toxic metals which includes the steps of:

a. sequentially rotating a plurality of adjacently disposed blades and moving the latter downwardly in said impoundment to form a plurality of overlapping zones of cuttings of said waste material;

b. allowing said cuttings to remain in place in said zones;

c. reversing the direction of rotation of said blades after said zones have been formed to a desired depth in said impoundment;

d. moving said blades upwardly after the direction of rotation of said blades have been reversed; and

e. discharging a mixture of chemicals adjacent said blades as they are moved upwardly in said zones, said mixture of chemicals transforming said waste hydrocarbon products to water insoluble solid and said water soluble salts of toxic metals to substantially insoluble oxidizes thereof.

22. An insitu method of treating a desired portion of a geographical expanse of hazardous waste that may contain toxic organic and inorganic substances in the from of solids, liquids and gases that are at least in part water soluble into an inert, insoluble mass that may remain in place without danger of said organic and inorganic substances leaching therefrom, said insitu method comprising:

a. providing a movable confined space above said geographical expanse and in sealing contact therewith at a first station;

b. forming a downwardly extending zone of said hazardous waste below said movable confined space into a plurality of particles that remain in place;

c. transforming said particles in said zone to a non-toxic state;

d. directing toxic gases released in said zone as said particles are formed upwardly into said confined space to mix with air in the latter;

e. removing said toxic gases from said air in said confined space;

f. moving said confined space to a second station that overlaps said first station and repeating said method.

23. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, and said transforming including the step of discharging a detoxifying agent into said zone as said cutting blade moves longitudinally in said zone.

24. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, with said transforming including the step of discharging a detoxifying agent into said zone as said zone, and that also serves to cement said particles into a solid, inert insoluble mass.

25. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, with said transforming including the step of discharging a detoxifying agent into said zone as said cutting blade moves longitudinally in said zone, and said insitu method including the further step of:

g. discharging a plurality of jets of a presurized liquid into said zone as said cutting blade moves longitudinally in said zone to further reduce said particles in size and provide a liquid seal that minimizes the flow of said toxic gas from said zone to said confined space.

26. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, with said transforming including the step of discharging a liquid media of microorganisms and a nutrient therefor into said zone as said blade moves upwardly in said zone, with said microorganisms of a species that biodegrades said toxic substances to non-toxic material that remains in place in said zone.

27. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, and said transforming including the step of subjecting said particles to the action of at least one plasma arc as said blades move upwardly in said zone, with said particles below said rotating blade as it moves upwardly being malted to define a solid, vitrified, insoluble mass of substantial strength.

28. An insitu method as defined in claim 22 in which said particles are formed by the movement of a rigid member in said zone, and said method including the further step of:

g. sampling the composition of said particles as they are formed in said zone, and discharging a detoxifying agent into said zone in an amount that is capable of transforming particles of said composition to a non-toxic state.

29. An insitu method as defined in claim 22 in which said toxic waste in said zone is formed into said particles by moving a rotating blade upwardly and downwardly in said zone, and said transforming is effected by discharging a detoxifying agent into said zone as said blade is moved longitudinally therein, and said method including the further step of:

g. sampling the composition of said particles in said zone, with said detoxifying agent being one that is effective in detoxifying particles of the composition found in the sample.

30. An insitu method as defined in claim 22 in which sulphur dioxide and hydrogen sulphide are present in said zone and said transforming including the step of discharging detoxifying agents into said zone to detoxifying said particles and reduce said sulpher dioxide and hygrogen to elemental sulphur, hygrogen and oxygen.

31. An insitu method as defined in claim 22 in which said particles are not only transformed to a non-toxic state but bonded together into a water impervious mass, and a succession of said zones of water impervious mass being formed at second stations completely around the periphery of said geological expanse to act as a barrier to contain said hazardous waste within the interior thereof.

32. An insitu hazardous waste impoundment detoxifying apparatus that includes a power driven vehicle; an elongate vertically extending frame supported from said vehicle, said frame including a lower end; a power driven hollow Kelly rotatably and vertically movable relative to said frame, said Kelly including a lower end; a cutting blade supported from said lower end, said cutting blade including a discharge open lug for a detoxifying agent, said apparatus being characterized by:

a. a confined space defining shroud supported from said lower end of said frame and disposable in sealing contact with the upper surface of said impoundment, and said cutting blade when rotated and moved downwardly in said impoundment creating a vertically extending zone of particled hazardous waste;

b. first means for discharging a detoxifying agent downwardly through said hollow Kelly and discharge opening into said zone;

c. second means for discharging at least one spray of liquid into said confined space to scrub toxic gases from the air therein, with the scrub liquid flowing downwardly from said shroud into said zone of particled waste to be detoxified.

33. A detoxifying apparatus as defined in claim 32 which is further characterized by:

d. third means for discharging a spray of pressurized fluid into zone above said cutting blade to assist said cutting blade in forming said zone and mixing with said particles to create a turbulent layer that acts as a moving seal to minimize the upward flow of toxic gases from said zone to said confined space in said shroud;

34. A detoxifying apparatus as defined in calim 32 which is further characterized by:

d. third means for discharging a pressurized non-toxic gas downwardly through said Kelly and discharge opening to displace toxic gases in said zone upwardly into said confined space in said shroud.

35. An insitu hazardous waste impoundment detoxifying apparatus that includes a power driven vehicle; an elongate vertically extending frame supported from said vehicle, said frame including a lower end; a power driven hollow Kelly rotatably and vertically movable relative to said frame, said Kelly including a lower end; a cutting blade supported from said lower end, said cutting blade including a discharge open lug for a detoxifying agent, said apparatus being characterized by:

a. a confined space defining shroud supported from said lower end of said frame and disposable in sealing contact with the upper surface of said impoundment, and said cutting blade when rotated and moved downwardly in said impoundment creating a vertically extending zone of particled hazardous waste;

b. plasma torch means on said cutting blade for melting said particles and converting same to a solid vitrified mass.

AMENDED CLAIMS
[received by the International Bureau on 21 January 1986 (21.01.86);
original claims 7,8,11,12,18,19,21,23,25-31 unchanged; other claims amended
(10 pages)]

1. A movable apparatus for the insitu forming and detoxifying of adjacently disposed downwardly extending zones of particled material in a hazardous waste impoundment without contaminating the ambient atmosphere, which waste impoundment may contain toxic organic and inorganic compounds as well as gases, said apparatus including a power driven vehicle; an elongate vertically extending frame movably supported from said vehicle; a plurality of horizontally spaced, vertically extending Kellys disposed within said frame and rotatable and vertically movable relative thereto, said Kellys having lower ends, said apparatus characterized by:

a. power means for rotating said Kellys that are adjacently disposed in opposite directions;

b. a plurality of cutting blades supported from said lower ends for forming said zones of particled material as said Kellys are rotated and moved downwardly relative to said frame, said cutting blades of such configuration that those that rotate in a clockwise direction move said particles cut thereby in a direction to intermingle with particles cut by said blades rotating in a counter clockwise direction to obtain a plurality of adjacently disposed zones in which said particles are substantially uniformly distributed;

c. first means that extend downwardly from said frame to said waste impoundment to define a confined space through which said cutting blades may be moved downwardly to form said zones;

d. second means for discharging a flowable agent into said zones for detoxifying the latter; and

e. third means for removing toxic material that has entered the air in said first means from said zones prior to said air being released to the ambient atmosphere.

2. A movable apparatus as defined in Claim 1 that is further characterized by including:

f. fourth means for sampling said waste as said zones are formed to determine the composition thereof and permit the selection of an agent for said second means that is appropriate for detoxifying said particles in said zones.

3. A movable apparatus as defined in Claim 1 that is further characterized by including;

f. fourth means for discharging pressurized water into said zones above said cutting blades to assist said cutting blades in forming said zones and mixing with said particles to create a turbulent layer that acts as a movable seal to minimize the upward flow of toxic gases from said zones into said confined space of said first means.

4. A movable apparatus as defined in Claim 1 in which at least one of said flowable agent supplied by said second means is a flow of pressurized air that displaces gases from said zones upwardly into said confined space defined by said first means.

5. A movable apparatus as defined in Claim 1 in which at least one of said flowable agents supplied by said second means is a flow of steam that volatalizes said toxic organic compounds having a low boiling point and causing the vapor thereof to flow upwardly into said confined space.

6. An insitu method for sequentially forming and detoxifying adjacently disposed, downwardly extending zones of particled material in a hazardous waste impoundment that may contain water soluble toxic compounds and gases without contaminating the ambient atmosphere, said method comprising the steps of:

a. defining a first confined space at a first station on said impoundment;

b. rotating a plurality of adjacently disposed cutting blades downwardly through said waste impoundment beneath said confined space at said first station to form a plurality of vertically disposed, overlapping zones of particles of said waste, which particles are allowed to remain in place in said zones;

c. injecting an agent into said zones prior to said blades being withdrawn therefrom, said agent being one that detoxifies said zones; and renders said water soluble toxic compounds insoluble;

d. removing all toxic material from the air in said confined space that has entered the latter from said zones prior to releasing said air to the ambient atmosphere;

e. moving said confined space to a second station adjacent said first station;

f. repeating said method at said second station and so continuing until a desired portion of said waste impoundment has been detoxified.

9. An insitu method as defined in claim 6 in which said hazardous waste may contain radium 226 and thorium 230 from which radon is emitted due to radioactive decay, with said chemical being added in an amount sufficient to precipitate said radium and thorium and transform them and said hazardous waste into a solid, inert insoluble mass of such high density that the rate of migration of radon therethrough is slowed to the extent that the major portion of the radon transforms to a solid radionuclide element prior to reaching the ambient atmosphere to contaminate the latter, with waste radionuclide element being rendered insoluble by contact with said chemical and remaining in place in said insoluble mass.

10. An insitu method of treatment as defined in claim 6 which includes the further steps of:

g. recovering gaseous products discharging from said waste in said first confined space as a result of forming said zones;

h. scrubbing undesirable chemical compounds from said gaseous products; and

i. discharging said gaseous products free of said undesirable chemical compounds to the ambient atmosphere.

13. An insitu method as defined in claim 6 in which each of said blade includes a pair of oppositely pitched portions to impart a downward and upward screwing action to said hazardous waste in said zones to obtain optimum homogenization of said waste in said zones as well as optimum mixing efficiency of said agent therewith.

14. An insitu method as defined in claim 6 in which said agent is selected from the group comprising calcium oxide, sodium bisulfite and sodium hydrosulfite.

15. A method for the insitu detoxification of a hazardous waste impoundment that contains water, waste hydrocarbon products in the form of oils and solvents and water soluble salts of toxic metals without contaminating the ambient atmosphere, said method including the steps of:

a. providing a confined space at a first station on said waste impoundment;

b. forming a plurality of adjacently disposed, overlapping downwardly extending zones of particles of said waste below said confined space;

c. saponifying said waste hydrocarbon products in said plurality of zones to a water insoluble mass;

d. oxidizing said water soluble salts of toxic metals in said plurality of zones to a substantially water insoluble state;

e. collecting fumes and gases from said saponifying and oxidizing in said confined space;

f. scrubbing said fumes and gases from air in said confined space; and

g. moving said confined space to a second station adjacent said first station and repeating said method.

16. A method as defined in claim 15 in which said plurality of zones are formed by concurrently rotating and moving downwardly in said impoundment a plurality of convex-concave rigid blades, and leaving the cuttings resulting from the rotation of said blades in said waste impoundment to provide said particles.

17. A method as defined in claim 16 in which said solidification of said waste hydrocarbon products and toxic metal salts is achieved by reversing the direction of rotation of said blades and moving said blades upwardly in said impoundment to intermix said particles and concurrently discharging calcium oxide into said plurality of zones adjacent said blades, said calcium oxide interacting with said water to provide an exothermic reaction in which said hydrocarbon products are transformed to a solid water insoluble mass, and said water soluble salts of said toxic metals are transformed to substantially water insoluble oxides.

20. A method as defined in claim 15 which includes the further step of:

d. establishing a pH of between 8.0 to 11.0 on said particles in said zones to facilitate said oxiding of said water soluble salts of toxic metals to a substantially water insoluble state.

22. An insitu method of treating a desired portion of a geographical expanse of hazardous waste that may contain toxic organic and inorganic substances in the form of solids, liquids and gases that are at least in part water soluble into an inert, insoluble mass that may remain in place without contaminating the ambient atmosphere and without danger of said organic and inorganic substances leaching therefrom, said insitu method comprising:

a. providing a movable confined space above said geographical expanse and in sealing contact therewith at a first station;

b. forming a downwardly extending zone of said hazardous waste below said movable confined space into a plurality of particles that remain in place;

c. transforming said particles in said zone to a non-toxic state;

d. directing toxic gases released in said zone as said particles are formed upwardly into said confined space to mix with air in the latter;

e. removing said toxic gases from said air in said confined space;

f. moving said confined space to a second station that overlaps said first station and repeating said method.

24. An insitu method as defined in claim 22 in which said particles are formed by rotating at least one cutting blade downwardly and then upwardly in said zone, with said transforming including the step of discharging a detoxifying agent into said zone, and that also serves to cement said particles into a solid, inert insoluble mass.

32. A movable apparatus for sequentially forming and detoxifying insitu adjacently disposed downwardly extending zones of particled material in a hazardous waste impoundment without contaminating the ambient atmosphere which waste impoundment may contain toxic organic and inorganic compounds as well as gases, said apparatus including a power driven vehicle, an elongate vertically extending frame supported from said vehicle, a plurality of horizontally spaced, vertically extending power driven kellys rotatably and vertically movable relative to said frame, each of said kellys having a lower end; a plurality of cutting blades supported from said lower ends for forming said zones of particled material as said kellys are rotated and moved downwardly relative to said frame, each of said blades including a nozzle, said apparatus being characterized by:

a. first means that extend downwardly from said frame to said waste impoundment to define a confined space through which said cutting blades may be moved downwardly to form said zones;

b. second means for sampling the composition of said waste impoundment as said zones are formed;

c. third means for discharging a flowable agent downwardly through said kellys and nozzles into said zones that is appropriate for detoxifying said waste of said composition determined by said second means; and,

d. fourth means for removing toxic material in the air in said confined space prior to said air being released to the ambient atmosphere.

33. A detoxifying apparatus as defined in claim 32 which is further characterized by:

e. fifth means for discharging a spray of pressurized fluid into zone above said cutting blade to assist said cutting blade in forming said zone and mixing with said particles to create a turbulent layer that acts as a moving seal to minimize the upward flow of toxic gases from said zone to said confined space in said shroud;

34. A detoxifying apparatus as defined in claim 32 which is further characterized by:

e. fifth means for discharging a pressurized non-toxic gas downwardly through said Kellys and discharge nozzles to displace toxic gases in said zone upwardly into said confined space in said shroud.

35. A movable apparatus for sequentially forming and detoxifying insitu adjacently disposed, downwardly extending zones of particled material in a hazardous waste impoundment without contaminating the ambient atmosphere which waste impoundment may contain toxic organic and inorganic compounds a portion of which may be radioactive, said apparatus including a power driven vehicle; an elongate vertically extending frame supported from said vehicle; a vertically extending rotatably and vertically movable relative to said frame, said kelly having a lower end; a cutting blade supported from said lower end for forming a zone of particled material as said kelly is rotated and moved downwardly relative to said frame, said apparatus being characterized by:

a. first means that extend downwardly from said frame to said waste impoundment to define a confined space through which said cutting blade may be moved downwardly to form said zone

b. plasma torch means on said cutting blade for melting said particles and converting same to a vitrified mass through which radon will not escape nor from which toxic material will leak out

c. second means for removing toxic gases and fumes from the air in said confined space of said first means prior to allowing said air to discharge to the ambient atmosphere.

FIG. 2

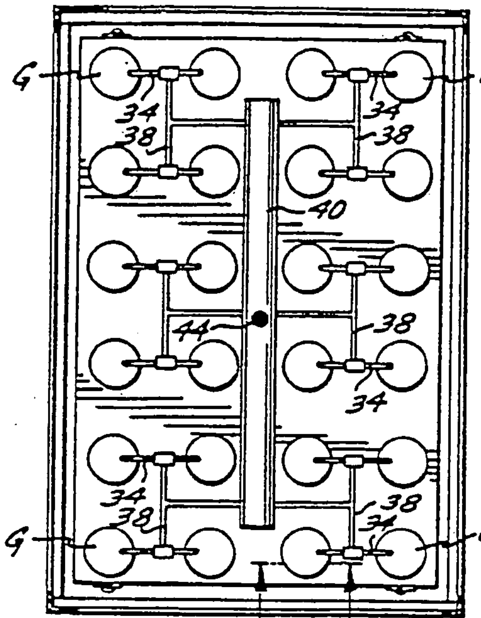


FIG. 3

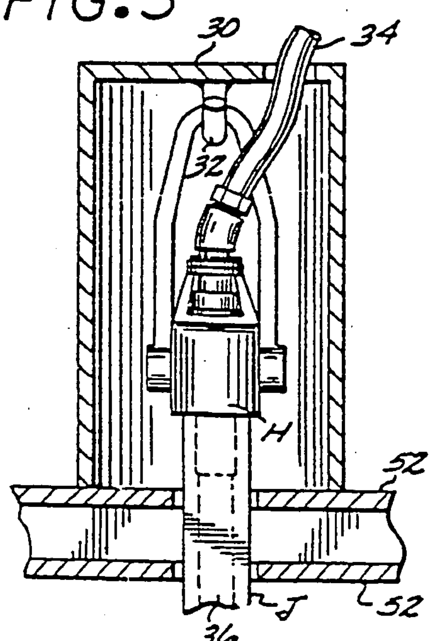


FIG. 1

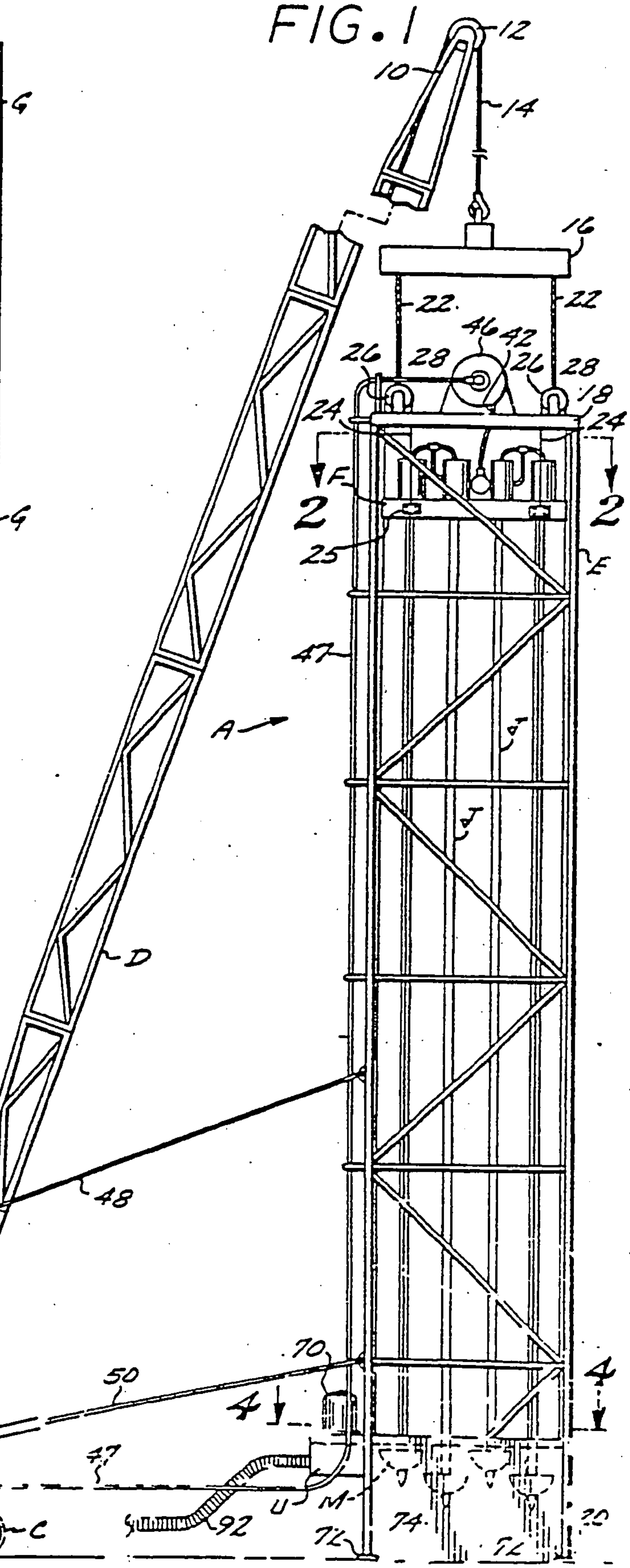


FIG. 4

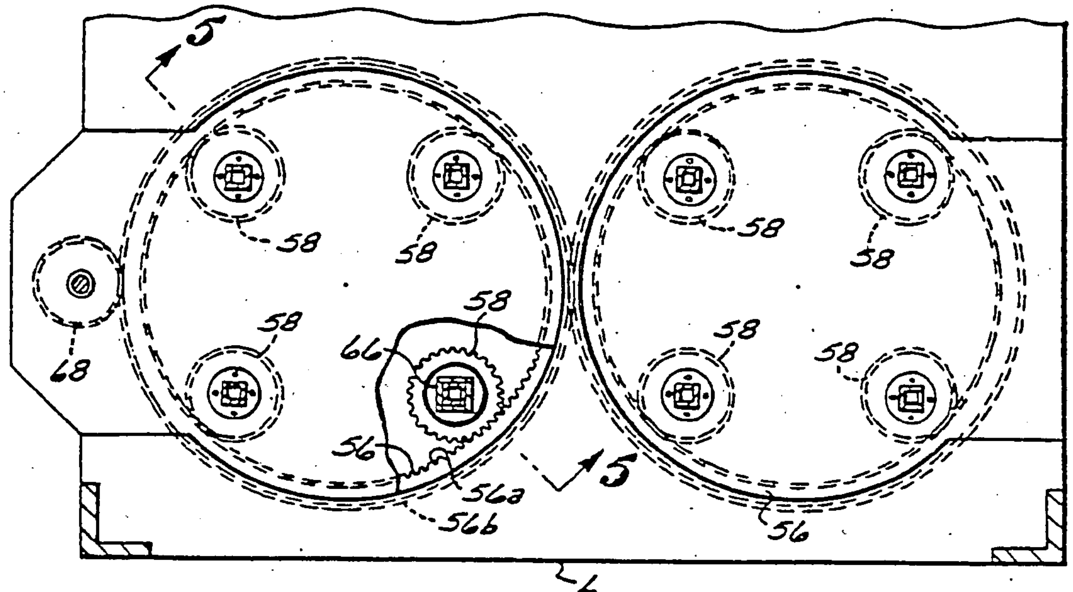


FIG. 5

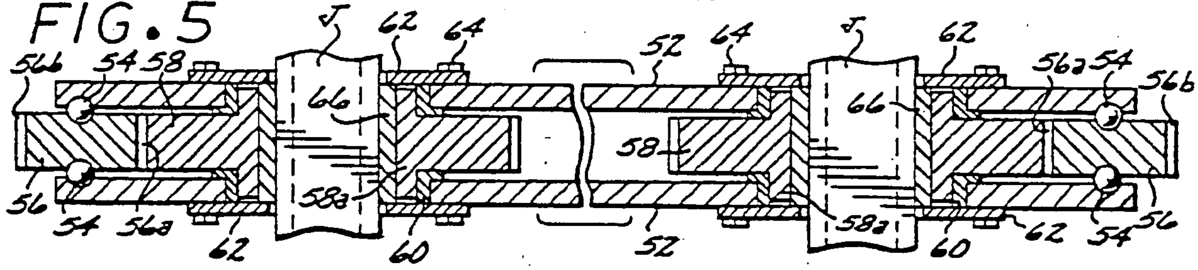
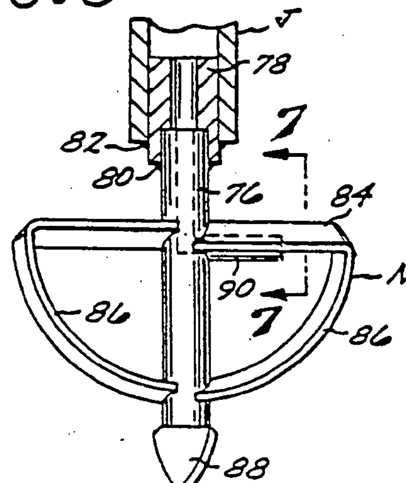


FIG. 6



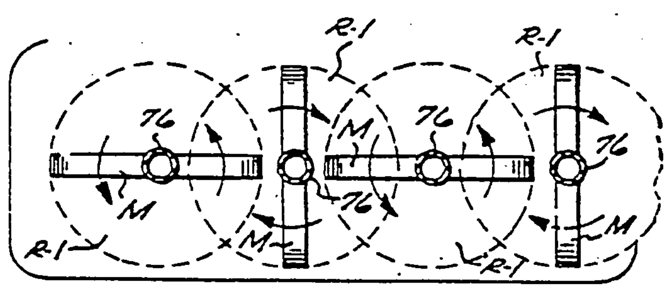


FIG. 8

FIG. 7

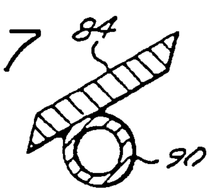


FIG. 9

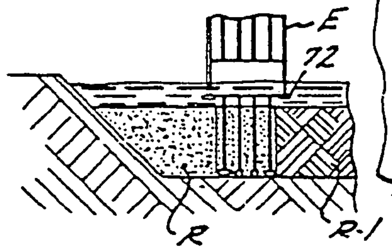


FIG. 10

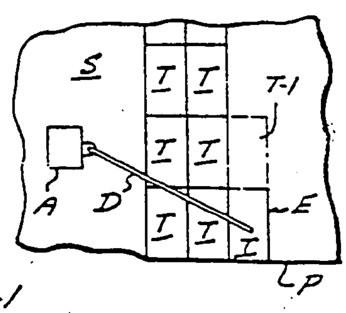
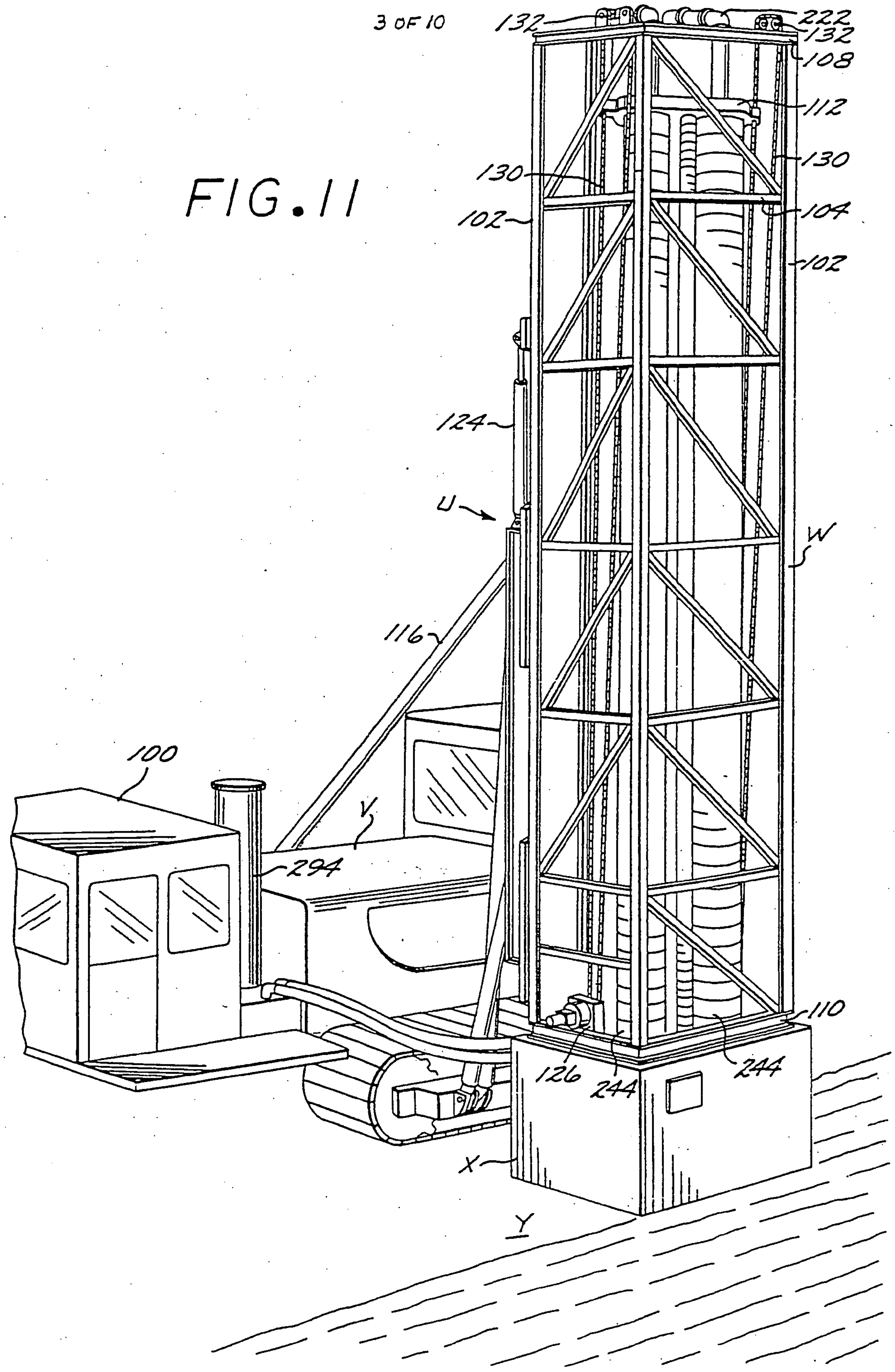


FIG. 11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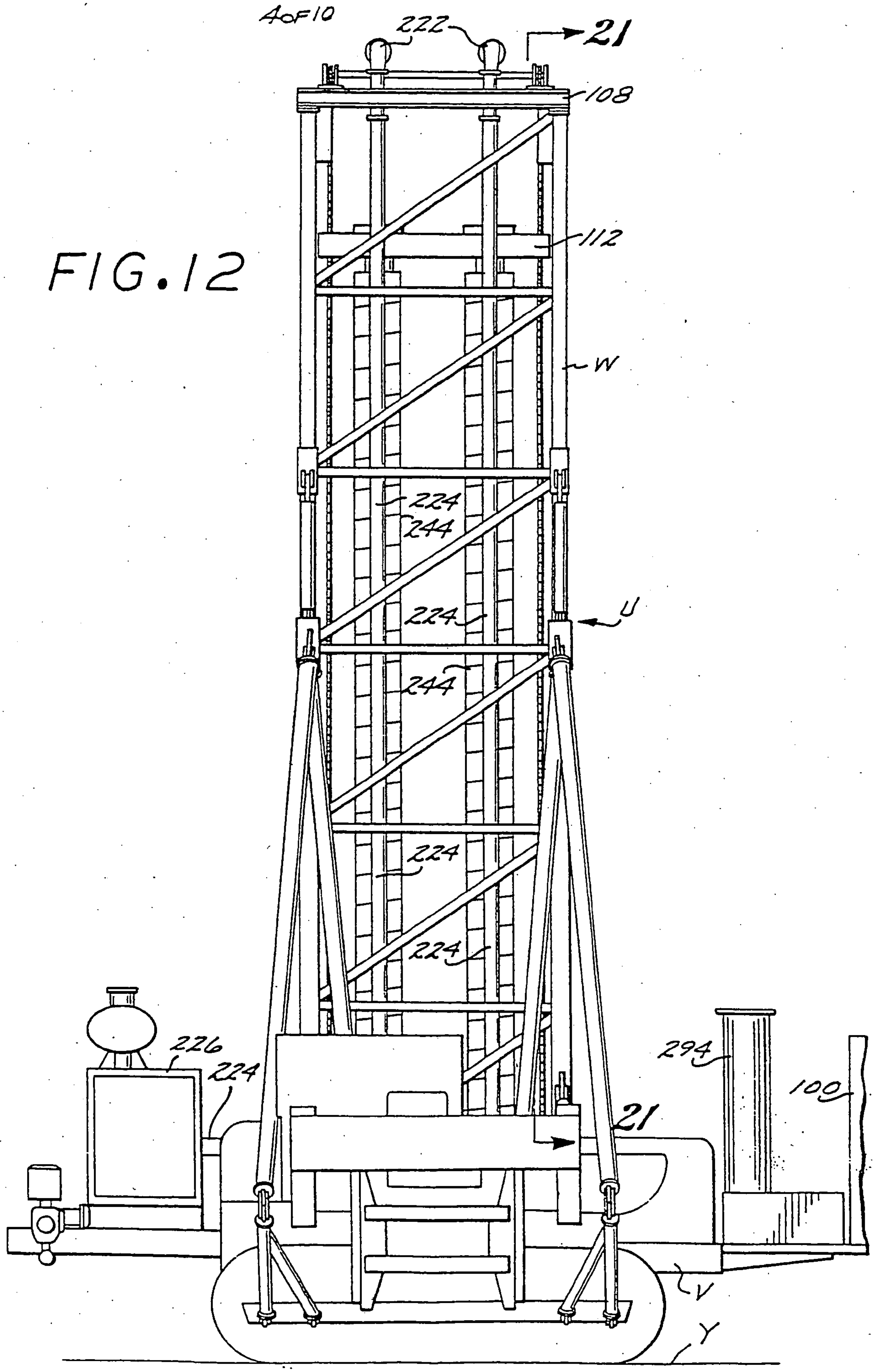

FIG. 12

FIG.14

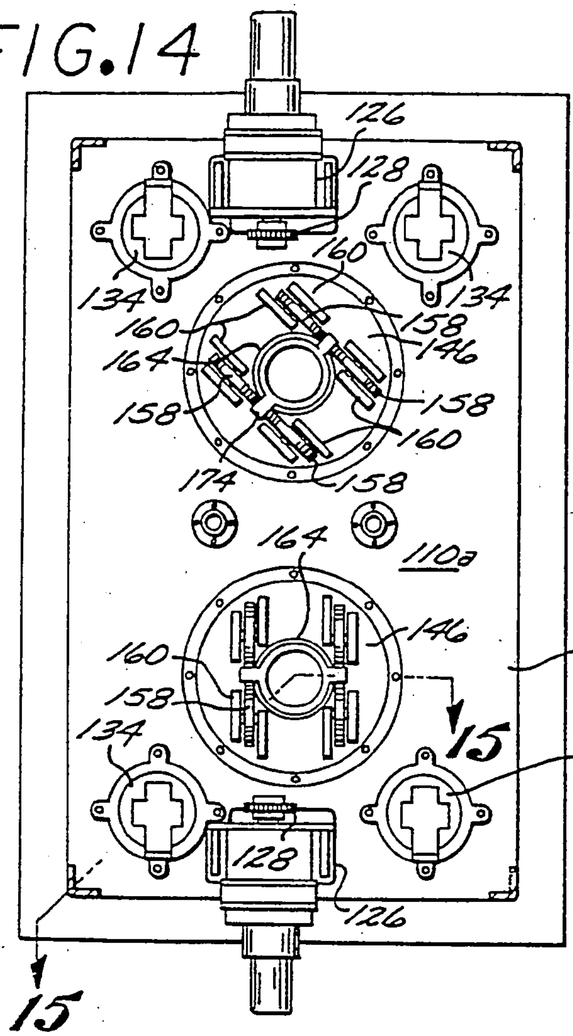
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FIG.13

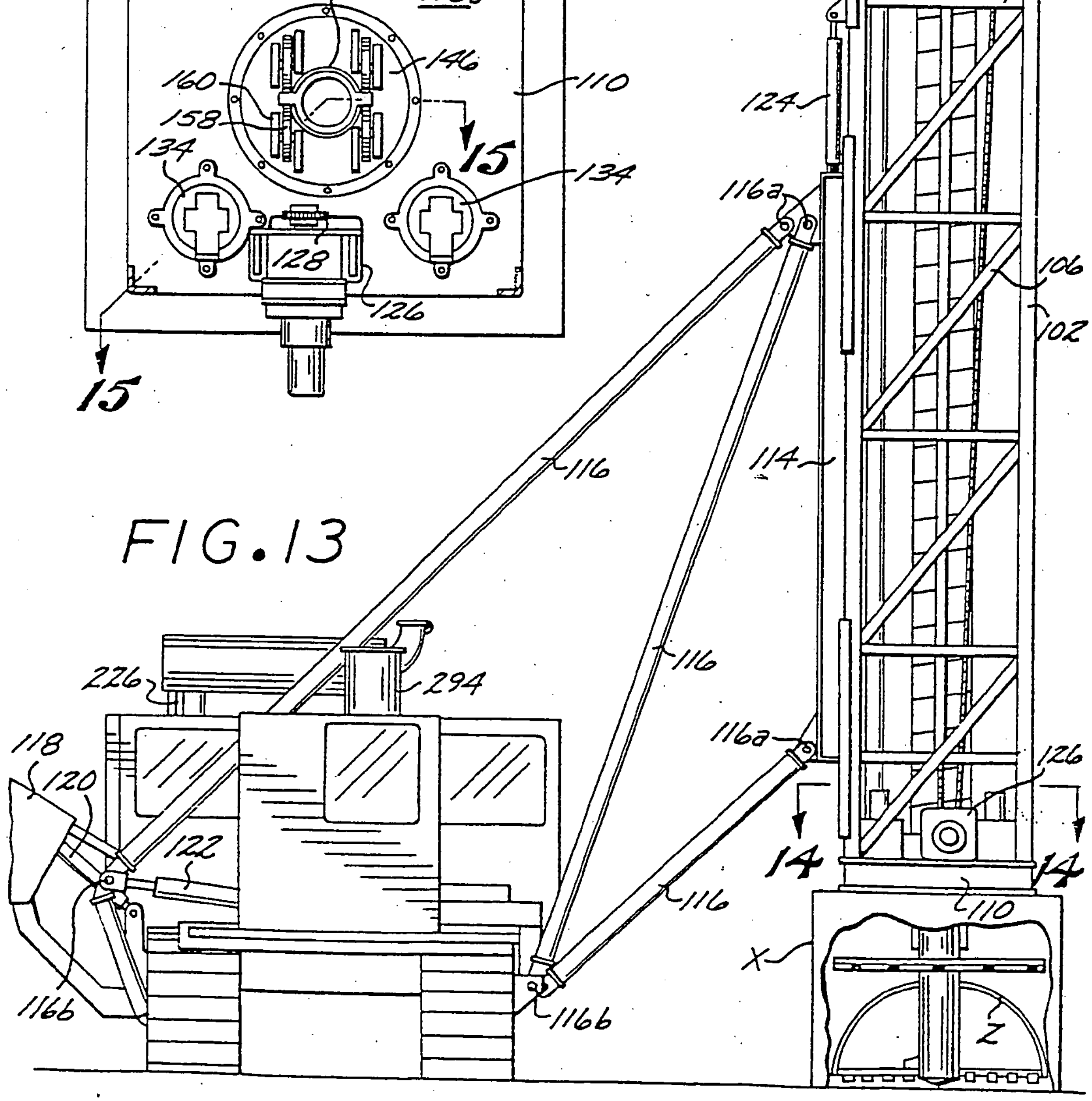
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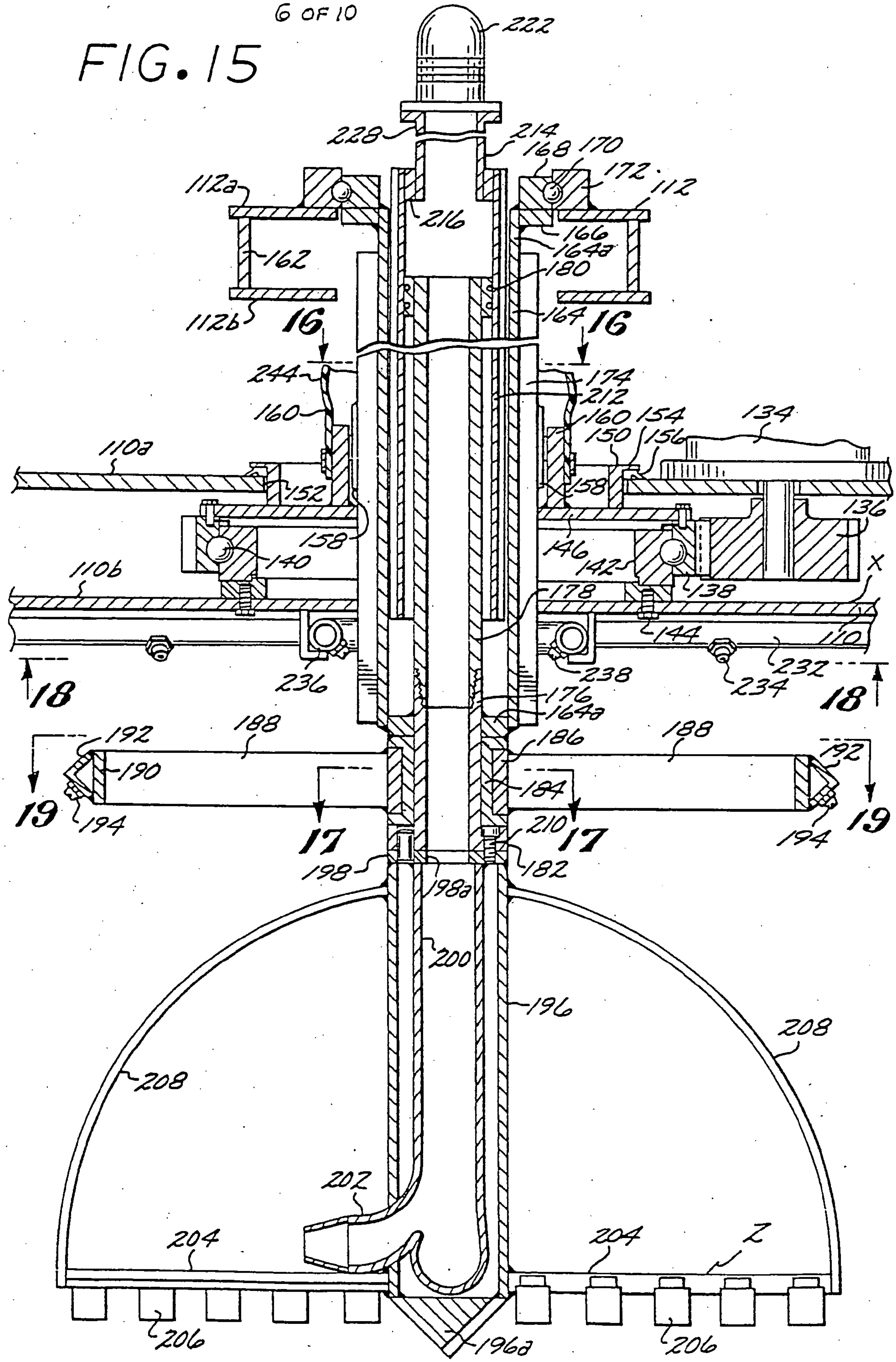
FIG. 15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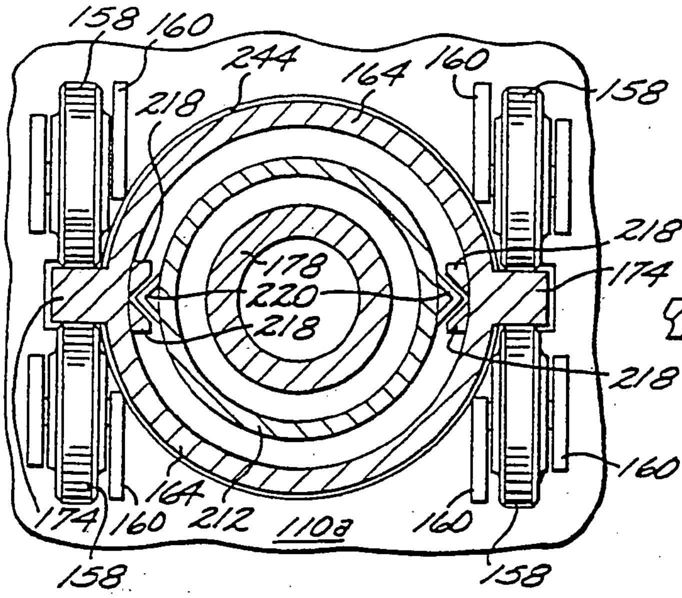


FIG. 16

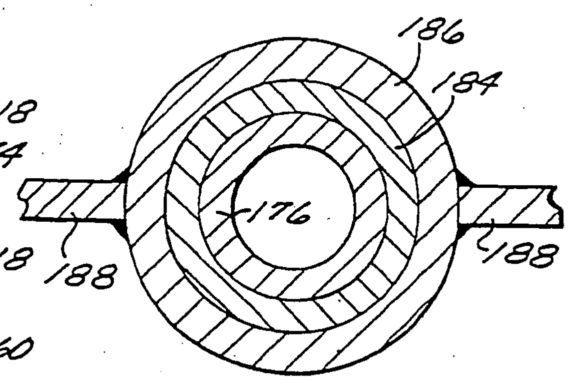


FIG. 17

FIG. 18

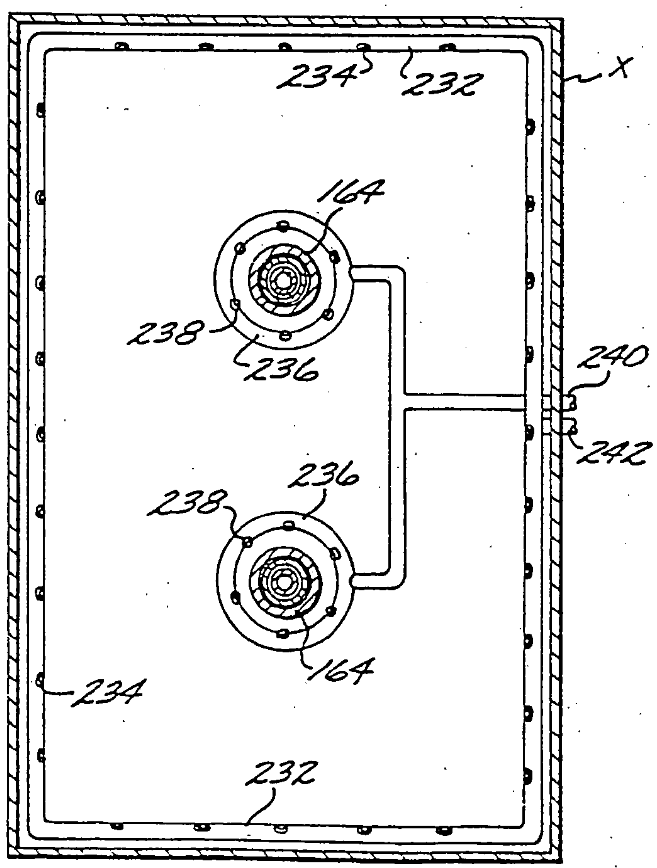


FIG. 19

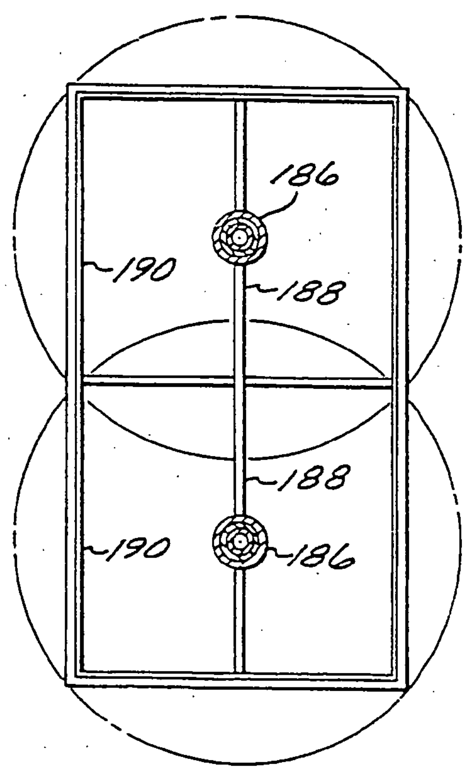


FIG.20

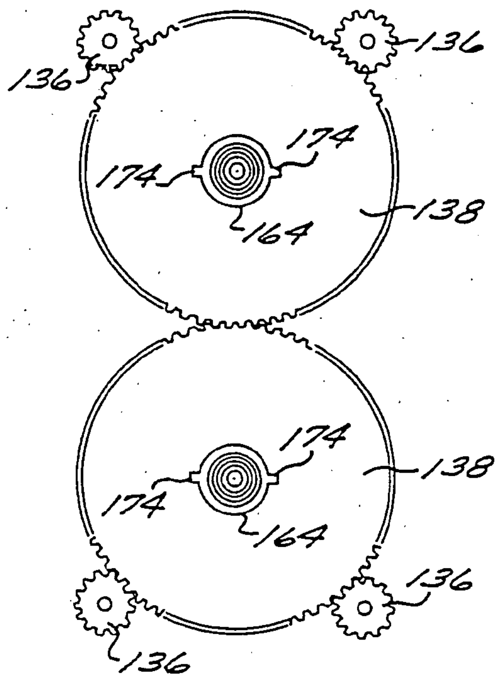


FIG.21

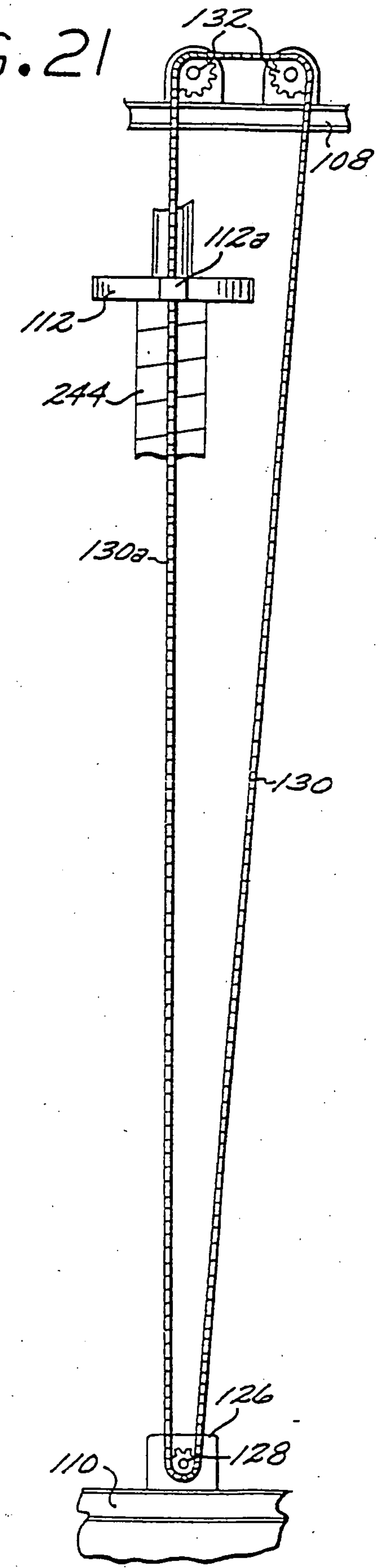


FIG.22

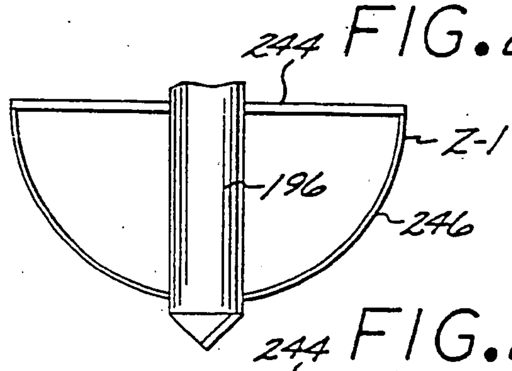


FIG.23

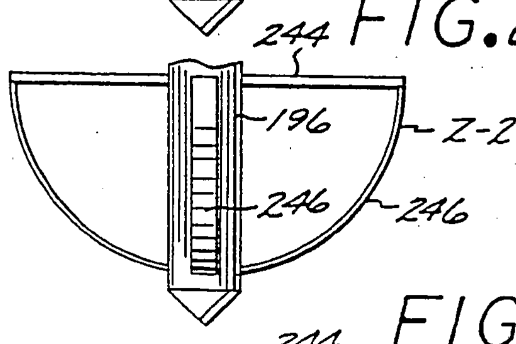


FIG.24

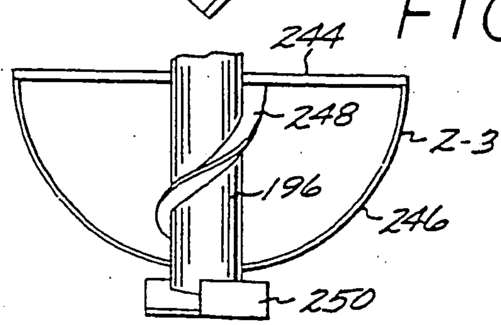


FIG.25

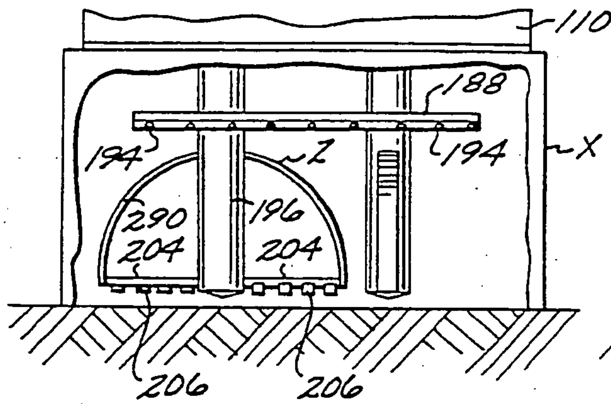


FIG.26

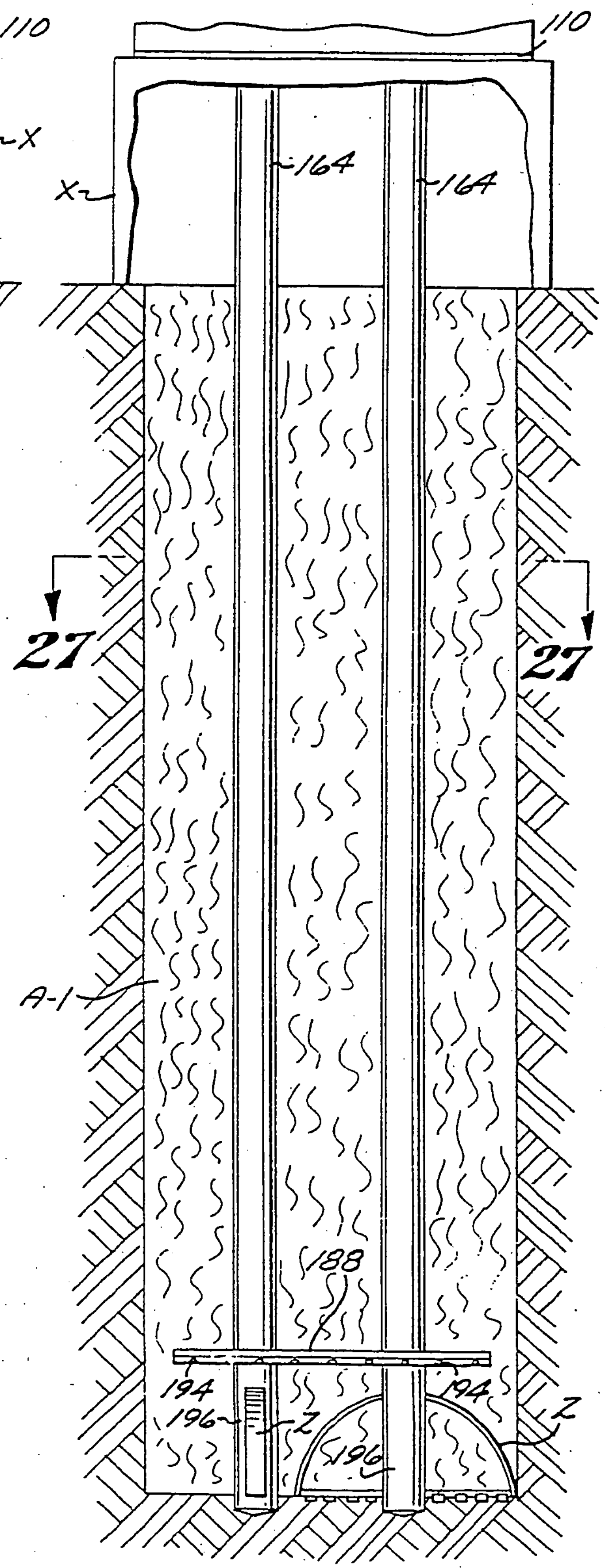
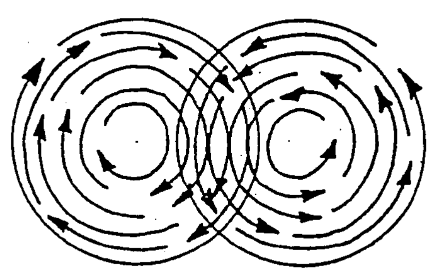


FIG.27



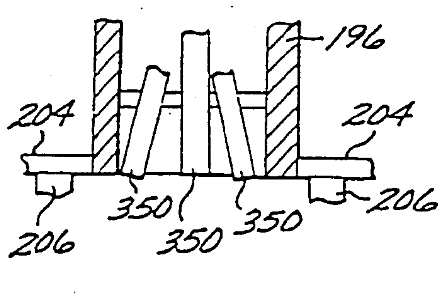
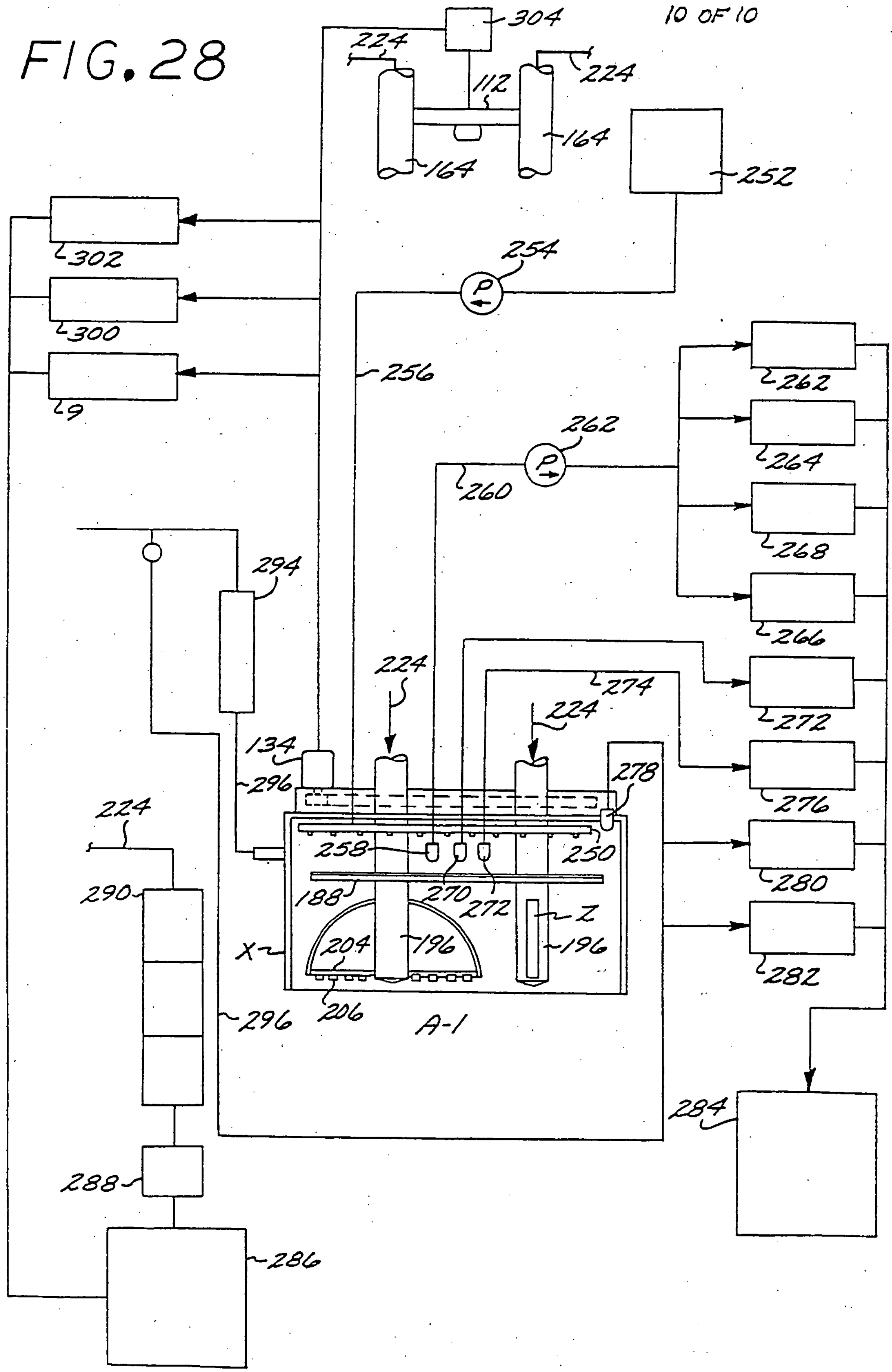


FIG. 28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INTERNATIONAL SEARCH REPORT

International Application No PCT/US85/01656

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 3

According to International Patent Classification (IPC) or to both National Classification and IPC INT. CL.4 B09B 1/00;G21F9/16;E02D5/18;G21F9/18;G21F9/24 U.S. CL. 405/128, 129,263,266-270;175/72;166/285,290,292,293;252/626,628,635;422/159; 219/69R

II. FIELDS SEARCHED

Minimum Documentation Searched 4

Classification System	Classification Symbols
U.S.	252/625-647; 264/0.5, 405/128, 129,258,263,266-270; 166/285,289,290,292,293; 422/159; 219/69R;210/751; 175/57, 72, 266/71,77;148/9R;106/74,76,78,89; 422/186.05, 186.23

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 5

LEXPAT(ALL US 1975-Date)

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

Category *	Citation of Document, 16 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No. 18
Y,E	US, A, 4,545,702 Published 08 October 1985, SANO et al.	1-25, 28-34
A,E	US, A, 4,544,499 Published 01 October 1985, TRAN et al.	1-35
A,P	US, A, 4,500,227 Published 19 February 1985, COURTOIS et al.	1-35
Y,P	US, A, 4,483,399 Published 20 NOVEMBER 1984, COLGATE	1-25, 28-34
Y	US, A, 4,456,400 Published 26 June 1984, HEIDE et al.	1-25, 28-34
Y	US, A, 4,442,028 Published 10 April 1984, WOLF et al.	1-25, 28-34
Y	US, A, 4,400,314 Published 23 August 1983, ELLIS et al.	1-25, 27-35
Y	US, A, 4,362,434 Published 07 December 1982, VALIGA et al.	1-25, 27-35

* Special categories of cited documents: 15

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 2	Date of Mailing of this International Search Report 2
18 November 1985	21 NOV 1985
International Searching Authority 1	**Signature of Authorized Officer 20**
ISA/US	JOHN F. TERAPANE SUPERVISORY PRIMARY EXAMINER Howard J. Locker

Form PCT/ISA/210 (second sheet) (October 1981)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	US, A, 4,352,601 Published 05 October 1982, VALIGA et al.	1-25, 28-34
A	US, A, 4,333,847 Published 08 June 1982, TRAN et al.	1-35
Y	US, A, 4,326,842 Published 27 April 1982, ADACHI et al.	27,35
Y	US, A, 4,269,706 Published 26 May 1981, SONDERMANN	1-25, 28-34
X,Y	US, A, 4,212,565 Published 15 July 1980, WATABE	1-25, 27-35
Y	US, A, 4,149,968 Published 17 April 1979, KUPIEC et al.	1-25, 28-34
Y	US, A, 4,086,325 Published 25 April 1978, CORDIER et al.	1-25, 28-34
X,Y	US, A, 4,084,383 Published 18 April 1978, KUKINO et al.	1-35
X,Y	US, A, 4,072,017 Published 07 February 1978, SHIRAKI	1-35
X,Y	US, A, 4,063,424 Published 20 December 1977, TAKAGI et al.	1-35
X,Y	US, A, 4,058,986 Published 22 November 1977, GRANHOLM	1-35
Y	US, A, 4,056,937 Published 08 November 1977, SUZUKI	1-35
A	US, A, 3,959,172 Published 25 May 1976, BROWNELL et al.	1-35
X,Y	US, A, 3,802,208 Published 09 April 1974, GRANHOLM et al.	1-35
A	US, A, 3,526,279 Published 01 September 1970, COLBURN	1-35
X,Y	US, A, 3,243,962 Published 05 April 1966, RATLIFF	1-25, 27-35
Y	US, A, 3,097,492 Published 16 July 1966, SALASSI	1-25, 28-34
X,Y	US, A, 3,023,585 Published 06 March 1962, LIVER	1-26, 28-34
A	GB, A, 2,134,919 Published 22 August 1984.	1-35

International Application No. PCT/US85/01656

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
A	FR, A, 2,524,351 Published 07 October 1983.	1-35

Form PCT/ISA/210 (extra sheet) (June 1980)

PCT/US85/01656

International Application No.

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

(See attached sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INFORMATION CONTINUED FROM ITEM VI. (LACK OF UNITY)

I. Claims 1-5, drawn to an injection and cutting apparatus for hazardous materials, classified in Class 422, Subclass 159.

II. Claims 6-10 and 14, drawn to a method of solidifying hazardous waste, classified in class 252, subclass 628.

III. Claims 11-13, drawn to a soil solidification method, classified in Class 405, subclass 129.

IV. Claims 15-20, drawn to a method of containing hazardous waste, classified in Class 252, subclass 635.

V. Claim 21, drawn to a method of solidifying hazardous waste, classified in Class 252, subclass 626.

VI. Claims 22-31, drawn to a method of fixing hazardous waste in the earth, classified in Class 405, subclass 128.

VII. Claims 32-34, drawn to an apparatus, classified in Class 422, subclass 159.

VIII. Claim 35, drawn to an apparatus including a plasma torch, classified in Class 219, subclass 69R.